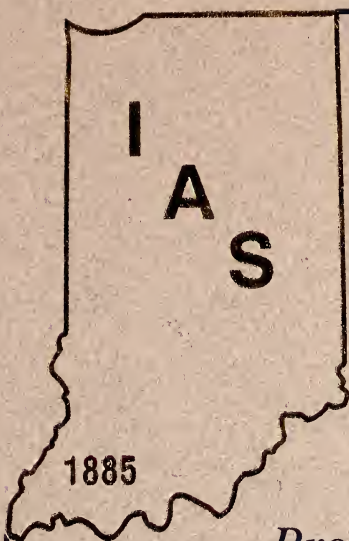




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PARALEMANEA SPECIES (RHODOPHYCEAE) IN CALIFORNIA

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ABSTRACT: The practice of applying European names to the American species of *Paralemanea* is questioned. New parameters, in large part not previously employed in the taxonomy of *Paralemanea*, are introduced. Five new species of *Paralemanea* from streams in the Western States are described, and recommendations for the future delimitation of species are made.

KEY WORDS: Rhodophyceae, red algae, *Paralemanea*, *Paralemanea brandegeei*, *Paralemanea californica*, *Paralemanea gardnerii*, *Paralemanea parishii*, *Paralemanea tulensis*.

INTRODUCTION

Paralemanea, formerly a subgenus of the genus of freshwater red algae, *Lemanea*, was recently elevated to the rank of genus (Vis and Sheath, 1992). Three species, *Paralemanea catenata*, *P. annulata*, and *P. mexicana*, were included in the new genus. Both *P. catenata* and *P. annulata* were recorded from eastern North America, while *P. annulata* was recorded from California.

Since early in the last century, American workers have customarily used names based on European types for North American collections of *Lemanea* (Subgenus *Paralemanea*). From 1887 on (Vis and Sheath, 1992), a few new names were added to apply to collections of American provenance. The European names have not proven, even in Europe, to refer to clearly and reliably separate entities. Most of the descriptive texts deal with the gametophyte axis, which is more frequently seen and collected, than with the sporophyte or "chantransia" stage, which is essentially a plant of winter. The descriptions, utilizing adjectives such as nodose-torulose, undulate-constricted, etc., are subject to a degree of personal interpretation as marked as the structural variability to which they apply.

The gametophyte body plan of *Paralemanea* (P. Silva) Vis and Sheath consists of a cylinder or axis with successive enlargements (nodes) and elongate intervening segments (internodes) attached by a stipelike basal end, usually to a rocky substratum in a stream. Many specimens are markedly nodose and have a beaded appearance, but in some collections, especially in the early growth stages and in the lower portions of the axis, the nodes are not visible externally. The degree of nodosity and the outline of the nodes are considered diagnostic characters (Pascher, *et al.*, 1925), but it remains to be seen if this character is geographically and temporally consistent and if it correlates with characteristics of the "chantransia" and the spores.

The gametophyte axis is so variable in form that it appears fruitless to attempt to identify a single plant or even several plants on the basis of axis outline alone. Other characters must be studied, and even then, at certain ages, the attempt to determine the species of a clump of gametophyte axes is likely to be futile. Nodal variability may be due to age, position on the plant, or other factors. In summer

collections, the lowest 2-6 nodes are generally narrower than the upper nodes and have smaller spermatangial areas or lack them altogether. The main portion of the axis, starting around node 4-6 and extending distally for 10-20 and potentially for 100 or more internodes, can be considered as a unit inasmuch as one internode repeats another with little structural variation. The term *mesothallus* will be used for this region. Above the mesothallus during much of the growing season, the axis becomes progressively narrower toward the tip, the internodes become shorter, the nodes become more prominent, and the axis ends distally in a minute filamentous embryonic region. Internally, these changes are accompanied by other changes in both vegetative and reproductive anatomy. Within the young mesothallus, a body cavity is present between the axis wall and the central strand; this cavity may ultimately be filled with carpospores. In the mesothallus, little change is observed in the central (axial) strand from its upper to its lower end. However, in the subtending stipe and the lowermost internodes, the central strand usually becomes more massive and the internal space or body cavity, which is characteristic of the greater part of the gametophytic axis, is absent. Hence, the axis wall is in direct contact with the central strand. In the upper axis above the young mesothallus, the central strand is narrower, reflecting the juvenile status of the distal tip. In this region, the beginnings of rhizoidal cortication of the axial filament are evident. In the mesothallus, the rhizoidal cortication is denser. Likewise, in the mesothallus, the number of cystocarps per internode, while variable, tends to be higher than in the basal 4-6 internodes (Figure 10) or in the distal portion of the axis where fertilization (if any) is more recent and cystocarp growth more jejune.

The foregoing discussion depicts the variability of a typical gametophyte axis in summer. As the plants grow and mature, pronounced seasonal changes in form occur. During this time, the problems of description due to intra-axis variability are compounded by maturation and senescence (i.e., by month-to-month variation in form during the growing period).

The early efforts to differentiate the species of *Paralemanea* centered on the gametophyte. The "chantransia" stage (presumably diploid in California *Paralemanea* (cf. Magne, 1967)) has been studied in European material by Sirodot (1872), and Bourrelly (1970) maintains that the "chantransia" may be necessary for species determination. For certain species, this may be true. Nevertheless, most of the various growth stages have the potential of providing diagnostic features; for example, the spermatangial bands exhibit a range of characteristic dimensions and outlines, and they have been used to delimit species (cf. Pascher, *et al.*, 1925); the cystocarps probably have characteristic ranges in number per internode within certain species; and the spores have been utilized by Blum (1993) for *Paralemanea* and by Jao (1941) for *Lemanea* in the description of new species.

The above remarks suggest a flaw in the original species descriptions from Europe. Due to the observed variation from winter to fall, the identification process becomes one of applying terms wanting in accuracy to plants subject to wide morphological changes over the growing season. Keying-down becomes inconclusive or delusive. The range of names (which appears adequate to provide a systematic framework for this genus) may lull one into a sense of security and

satisfaction vis-a-vis the genus as it appears in standard manuals, when actually it is fair to ask whether anyone is capable of utilizing these descriptions with understanding and precision (cf. Israelson, 1942, p. 16).

The contention advanced in this paper is that the California flora does not include taxa of *Paralemanea* named (as species of *Lemanea*) from Europe or eastern North America. The California species are considered distinct from those of eastern North America. Thus, other American species can be ignored, and our attention focused on the European species. If the European species are based on type specimens, each of which represents only one stage of development in a continuum of morphological change, a stage not necessarily comparable with the stages of development represented by the other species; if the descriptions are unclear, and the unique characters of the taxa have not been recorded; if imperfections in the original descriptions of the older, 19th century species now assigned to *Paralemanea* (excepting *Lemanea mexicana* Kütz.= *P. mexicana* (Kütz.) Vis and Sheath) are not removed either in the illustrations provided by the original author or in later manuals utilizing these species; then any precise resolution of the nomenclature is rendered impossible, and the California entities should receive new names. The demonstration of unique features in the California material, when compared with a broad sampling of European material, is an important and abetting factor in the contention that, as regards this genus, the European and the California floras appear to be mutually exclusive. Taxa based on collections from California are differentiated from other American and European taxa in this paper. For five taxa, new names in the genus *Paralemanea* are proposed.

MATERIALS AND METHODS

The material studied in this work came from herbarium specimens supplemented by collections made by the author in the period 1988-1993. Dried specimens of both the gametophyte and the "chantransia" were found to return readily, upon hydration, to a natural appearance and very nearly to natural size. Specimens preserved in formol or other preservatives were used, if available. An appreciable number of the herbarium specimens were too fragmentary for instructive study.

Hydrated gametophyte axes were stained with dilute rose bengal solution and cleared in 50% Karo to produce semipermanent slides. "Chantransias" were similarly treated, following separation-dissection and repeated washing of the dissected material. Occasionally, good "chantransia" material could be found at the base of a gametophyte axis. All sections of gametophyte thalli were made freehand from dry or slightly hydrated axes. If available, three axes were sectioned together until approximately 60 sections were obtained. These sections were stained, cleared, and mounted together on the same slide. Spores, if sufficiently ripe, were studied from such sections or from crushed, stained, and cleared axes. Five characters were utilized as part of this study.

Rhizoids in the axial strand. Sections of the axis were used when counting (at 440x) the number of rhizoids surrounding the axial filament. Since corticating rhizoids are rare in the California specimens and since the central strand tends to follow a sinuous path through the thallus cavity, many sections were unsuitable

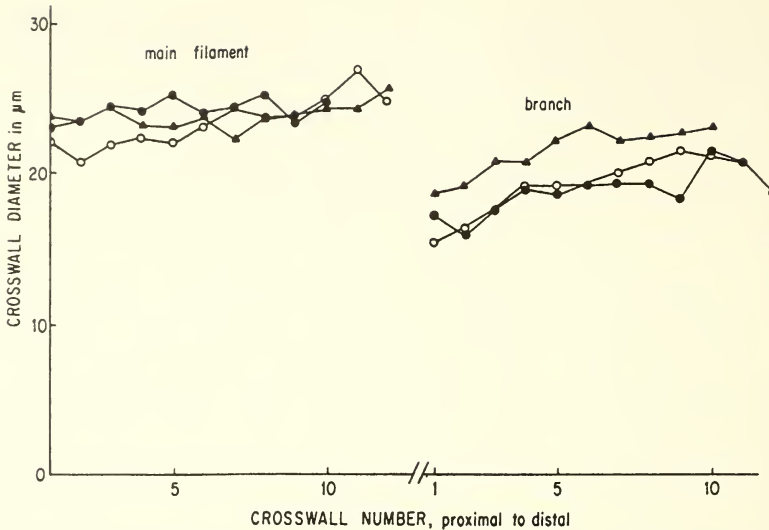


Figure 1. The crosswall diameters of three California "chantransias" having a main filament with primary branches distinctly inferior in thickness; the x-axis shows crosswall (i.e., cell) number. The collections represented are: *P. gardnerii*, F.R. Fosberg, T107, Borrego Valley, San Diego County, California (black circles; n=8; UC); *P. brandegeei*, Mrs. T.S. Brandegee, New York Ravine near Clarksville, Eldorado County, California (triangles; n=18; UC); and *P. californica*, C.L. Anderson, Santa Cruz, Santa Cruz County, California (open circles; n=7; FH).

for making such a count. Therefore, a variable number of useful sections (usually 10-20 from each collection) were used for rhizoid counts, which were then averaged. Rhizoid number in a collection varied within wide limits, and no statistical validity, based on such counts, can be claimed for the results from individual collections.

Distance from the Base of the Gametophyte to the Lowest Spermatangial Node. This distance was measured (at 440x), after the position of the lowest spermatangial node (which does not necessarily correspond with the first nodal enlargement) had been determined. The presence of at least 10 spermatangial cells was required to identify the lowest spermatangial node. The *Paralemanea* thallus, especially in the California specimens, is sufficiently translucent in the first few nodes and internodes to allow clusters of spermatangial cells to be observed through the thallus. Nevertheless, some error is introduced because the lowest spermatangial area, frequently a single spot, may occur where the curving edge of the mounted thallus obscures the epidermal structure. In addition, an entire axis (or at least its entire lower end) must be used in preparing a semipermanent mount. If the specimen packet contains only a few complete thalli, randomizing is impossible, and error is inevitable in the few counts which a single collection yields. For collections made expressly for this study, adequate numbers of thalli were generally available, but for many of the herbarium specimens, only 2-5 counts could be made.

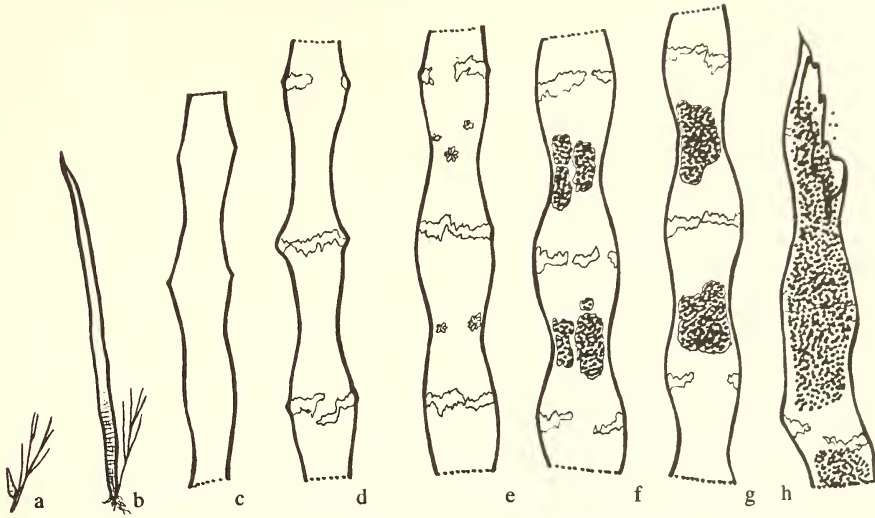


Figure 2. Diagrams representing “chantransias” and gametophytic thalli of *Paralemanea* at successive times in their growth. The “chantransia” at a has a juvenile gametophyte axis; at b, the gametophytic axis is older. Diagrams c-h show only a few nodes on progressively older axes. At c, the spermatangial bands are not yet visible. At d, the bands are visible, while at e, following fertilization, the beginning of cystocarp growth can be seen in the internode, if the axis has been cleared and stained. Much larger cystocarps are shown in f, and in g, the cystocarps have merged so that individual cystocarps can no longer be identified. In h, the spore masses from the cystocarps have conjoined, the decaying thallus wall has eroded, and the carpospores are being released.

Spermatangial Disposition. The spermatangial areas, consisting near the axis base of epidermal spots or sori, become complete rings about the upper nodes, and their width varies. Their width was measured using an ocular micrometer. An average of four to ten readings from random placements of the scale at each node from 1 through 14 or 15 were made. Spermatangial areas were recorded as spots, broken bands, or complete bands. The first two categories were regarded as incomplete; they included bands made up of a series of spermatangial areas forming a broken ring about the circumference of the node as well as those bands which completely encircled the node but were broken in such a way that their ends did not meet (Figure 2d). If the thalli from collections assigned to a single species gave conflicting results as to the number of the node representing the beginning of complete bands (*P. californica* and *P. gardnerii*), an average of the readings was taken (Figure 18). In the species descriptions in this paper, nodes 1-3 were disregarded when stating the limits of spermatangial band width, because the lowermost nodes frequently exhibit narrower bands, unrepresentative of the bands on superior nodes. An occasional incomplete band does sometimes interrupt an otherwise “complete” series; this incomplete band was disregarded in designating divisions of the thallus. Occasional outliers are encountered; i.e., spermatangial spots lateral to a band which are not connected to the band itself.

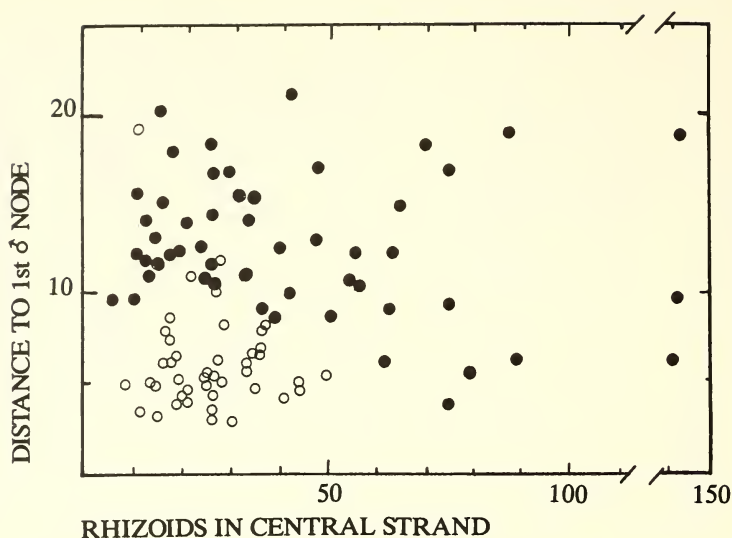


Figure 3. The rhizoids in the central strand (x -axis) plotted against the distance from the axis base to the lowest (1st) spermatangial area (y -axis). The black circles represent European collections; the open circles, California collections.

These outliers are most common in large specimens; they were measured and recorded as part of the spermatangial band, if the random line selected happened to cross them.

“Chantransia” Morphology. The young “chantransia” plant consists of an erect, uniseriate, unbranched, photosynthetic filament, whose basal end terminates in a colorless rhizoid. Additional rhizoids grow out of the lowermost cells of the photosynthetic filament. Both the photosynthetic axis and the rhizoids branch and rebranch. After branching begins, short photosynthetic branches, each initiated by an apical cell, form the young gametophytic axes. Certain “chantransia” plantlets become heavily tufted with many thickly-bunched branches. As the gametophytic axes grow rapidly in length, greatly surpassing the “chantransia,” the latter undergoes changes indicative of senescence: its filaments elongate, become crooked, and lose much of their pigmentation, approximating the rhizoids in appearance. The “chantransia” filaments may become colonized by a variety of epiphytes, and breakage and erosion occur. By late spring, the “chantransia” is likely to be greatly modified or completely gone.

The branching habit of the “chantransia” frustrates easy comparative description. Opposite branching and unilateral branching have been used as points of distinction (Sirodot, 1872), but for the California material, both these branching patterns appear to be universally present.

The presence or absence of a main filament to which the branches are both subsidiary and smaller as well as conic filaments which taper significantly from one end to the other appear to be potential diagnostic characters. These two traits were investigated by taking width measurements of successive cells at their crosswalls. Basal filaments (photosynthetic) were defined as those with free rhizoids attached at their base or whose base itself was becoming rhizoidal. The

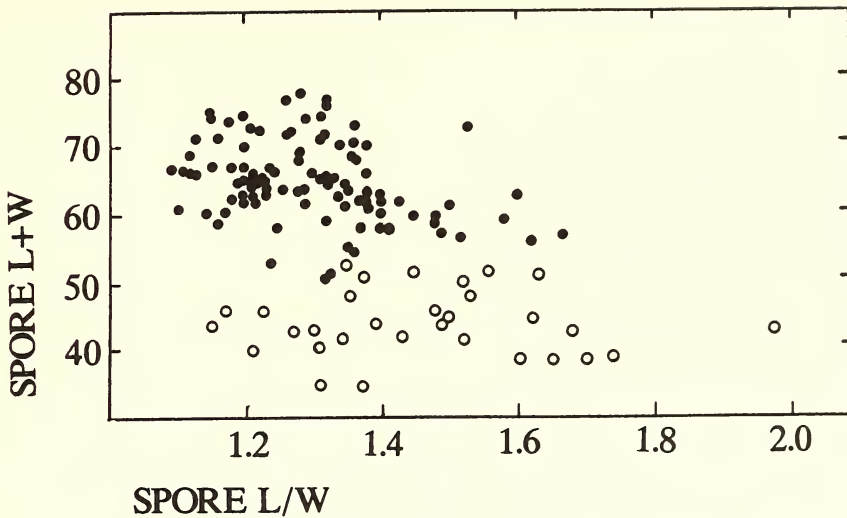


Figure 4. The ratio of spore length to width (μm , x -axis) plotted against the sum of spore length and width (μm , y -axis). The black circles represent collections from the eastern United States (essentially from the Missouri-Kansas boundary to the Atlantic); the open circles represent California collections plus a few from Oregon, Idaho, and Nevada.

diameter of the cells, if any, between the base and the first photosynthetic branch was recorded. The cross wall immediately above the first photosynthetic branch was considered the beginning of the main filament (although some main filaments were no greater in diameter than their branches). After measuring the crosswalls of all the cells in the main filament, a branch was selected, and similar measurements were made on the cells of the branch. For such measurements, plantlets were sought which had both an intact main filament and an intact branch of several cells apiece. Plants with broken tips were, insofar as possible, rejected, and older "chantransias" with elongate, crooked cells were considered atypical and were not measured. An outline sketch of each plantlet chosen was made after taking its measurements.

The presence or absence of a main filament is not an easy distinction to make in *Paralemanea*. Of the filaments in a tuft, one or two, older than the rest, may be perceptibly larger. This perception could be verified using the measurements described above. In the California "chantransias," such measurements revealed the presence of a principal filament in three of the species described here (Figure 1).

Size of "Chantransia" Terminal Branches. Since the branching pattern of the "chantransia" offered few reliable characters and the comparative study of basal and intermediate cell size appeared to promise no useful results, the terminals of the youngest photosynthetic "chantransia" filaments were chosen for diameter determination. Their diameter was measured at the most distal crosswall; where possible, fifteen determinations were made and averaged for each of the 27 California collections studied as well as for the 29 collections from the eastern United States and the 18 collections from Europe. No broken, pale,

Table 1. Average distance determinations (gametophyte thallus base to lowest spermatangial areas) in the various collections ranked by size class. N is variable in each collection ((2-) 5-10 (-30)).

California Collections	Eastern U.S. Collections	European Collections	Size Classes (mm)
8	0	0	2.1-4
29	7	1	4.1-6
16	33	4	6.1-8
7	28	6	8.1-10
3	22	9	10.1-12
0	33	21	12.1-14
0	22	11	14.1-16
0	11	5	16.1-18
0	2	3	18.1-20
0	0	3	20.1-22
0	0	0	22.1-24
Total	63	158	63

or elongated (senescent) terminals were included in the measurements. "Chantransias" not associated with any gametophytic parts were also avoided.

GROWTH OF THE GAMETOPHYTE

The growth of the gametophyte of *Paralemanea* can be summarized in a series of diagrams (Figure 2a-h). These stages can sometimes be recognized *in vivo*; however, whole mounts are usually needed to identify them. A young gametophyte axis consists of a few cells, one of which is the apical cell. This axis, growing from and attached to the "chantransia," is shown in Figure 2a. In b, the axis has grown to several hundred cells and retains its apical cell, but as yet, nodes and internodes are not externally visible.

Stages c-h represent a series of internodes in the mesothallus. Stages a-c have no recognizable spermatangial areas. A typical spring stage, d, is somewhat unpredictable in southern California due to the frequent and irregular desiccation of the stream beds. This stage (d) shows recognizable spermatangial areas but no visible cystocarps, which are small and subspherical in e. In f (approximately early summer), the cystocarps have enlarged but can still be counted. Later, the tip of the thallus thickens as the lower portions of the axis have previously done. In g, the cystocarps, after further growth, have joined into a mass of developing spores, usually more or less central in each internode. The spores mature, acquire a thick wall, and normally lose their attachment to other spores in the cystocarp. In h (July-November), the mass of enlarging spores has joined other spore masses creating at least locally a continuous internal column of spores. Then, the axis is broken and/or eroded, and the spores are disseminated by water.

The above sequence can be modified or interrupted at any time in an intermittent stream. The desiccated plants remain for a few weeks or perhaps until winter with or without having matured their spores. In some species, vegetative growth can resume from viable holdfasts which remain in or on the rocky substrate (Stewart, 1983).

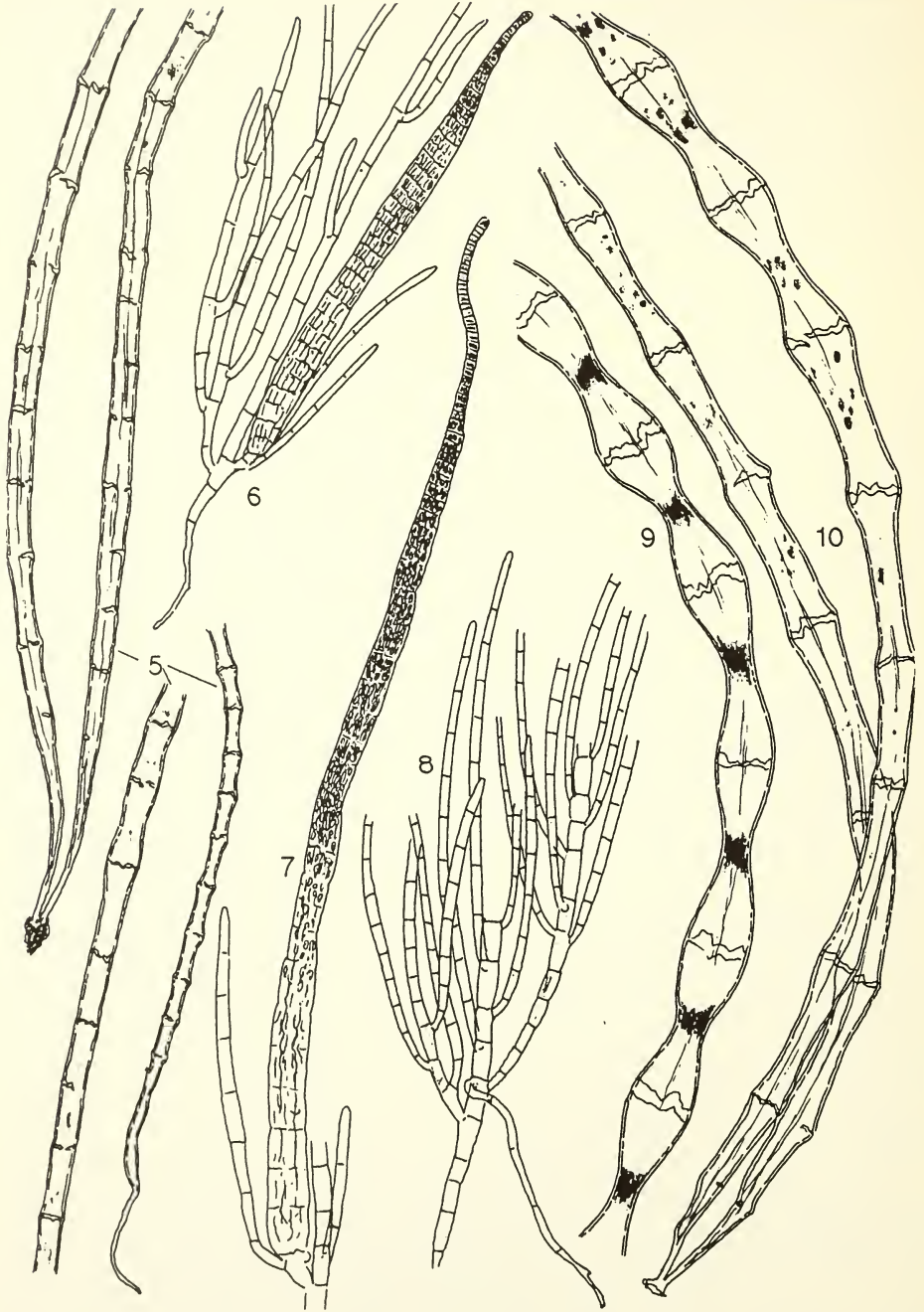
While stages a-h are defined by morphological events and structural features, the maturation of the gametophyte generally involves changes in shape. Frequently, the deformations may materially modify many or most of the axes in a collection. Some axes may mature before others. Certain internodes may produce spores, while others do not. The extent of these changes will affect the ultimate appearance of an internode and/or the entire axis. Therefore, this series (a-h) will not apply with accuracy to an entire collection or to any one species. The series (a-h) represents a schematized average of the appearance of the axes in any collection at certain times during the growing season.

DISTINGUISHING CHARACTERISTICS

The American Pacific Coast species differ from others with which they might be confused in three important characters: 1) the gametophyte axis bears spermatangial areas relatively close (4-8 mm) to its base, whereas in the European species, the spermatangial areas are farther away (8-21 mm; Table 1); 2) the corticating rhizoids of the central strand in the mesothallus are few (5-25 (-35)) in number, as seen on the cross-section, and show little tendency to cohere, whereas in species from the eastern United States, the corticating rhizoids are more abundant (20-250) and are regularly united about the axial filament in a coherent mass (the European species are similar to the West Coast species in this regard); and 3) the gametophyte of the West Coast species exhibits a banded appearance throughout the mesothallus during most of the warmer season when spores are present, the lighter nodal areas alternating with the darker, spore-bearing internodes (Figures 5, 9, 11, 14, 16). This phenomenon, with few exceptions, is not seen in material from the eastern United States or Europe. The banded appearance is particularly obvious after staining and clearing, but it is also visible in some dried specimens. In senescent California populations in the autumn, this character may be lost as the expansion of the spore mass ultimately fills the cavities of both the nodal and internodal areas (e.g., *P. tulensis* sp. nov.)

The California collections as a whole were compared with the European collections as a whole in preparing Figure 3, which contrasts their differences in the number of rhizoids and spermatangial position. While the accuracy of such a procedure is dependent on the number of collections sampled, and the 44 European collections are a meager group to represent either Europe or the rest of the world, the evidence suggests that none of the European names formerly applied to the California collections (e.g., *Lemanea torulosa* (Roth) Ag. or *L. catenate* Kütz.) are applicable to the material collected and studied to date.

The species from California and the eastern United States can be distinguished using two relatively simple measurements: 1) when carpospore size and shape are compared, the California spores are clearly smaller (Figure 4) and tend to be more elongate; and 2) the terminal cells of the primary and secondary branch filaments in the "chantransia" are narrower than those from eastern collections (Table 2).



Figures 5-10. 5. *Paralemanea gardnerii*, mature, spore-bearing gametophytes, TYPE (x10). 6. *P. gardnerii*, "chantransia" with juvenile gametophyte axis, TYPE (x150). 7. *P. californica*, young gametophyte axis showing proboscoid tip (x150). 8. *P. californica*, "chantransia" (x150). 9. *P. californica*, gametophyte axis, Blasdale collection (x10). 10. *R. californica*, gametophyte axes, TYPE (x10).

Table 2. The total number of “chantransias” arranged in size classes based on average terminal crosswall diameter. The populations from California are contrasted with the populations from the eastern United States.

California	Eastern U.S.	Size classes (µm)
0	0	10.0-10.9
2	0	11.0-11.9
4	0	12.0-12.9
2	0	13.0-13.9
5	0	14.0-14.9
4	1	15.0-15.9
4	3	16.0-16.9
0	2	17.0-17.0
0	12	18.0-18.9
1	5	19.0-19.9
0	3	20.0-20.9
0	3	21.0-21.9
0	5	22.0-22.9
0	3	23.0-23.9
0	0	24.0-24.9
0	1	25.0-25.9
0	0	26.0-26.9
0	0	27.0-27.9
0	0	28.0-28.9
0	0	29.0-29.9
0	0	30.0-31.9
0	1	31.0-31.9
Total	22	39

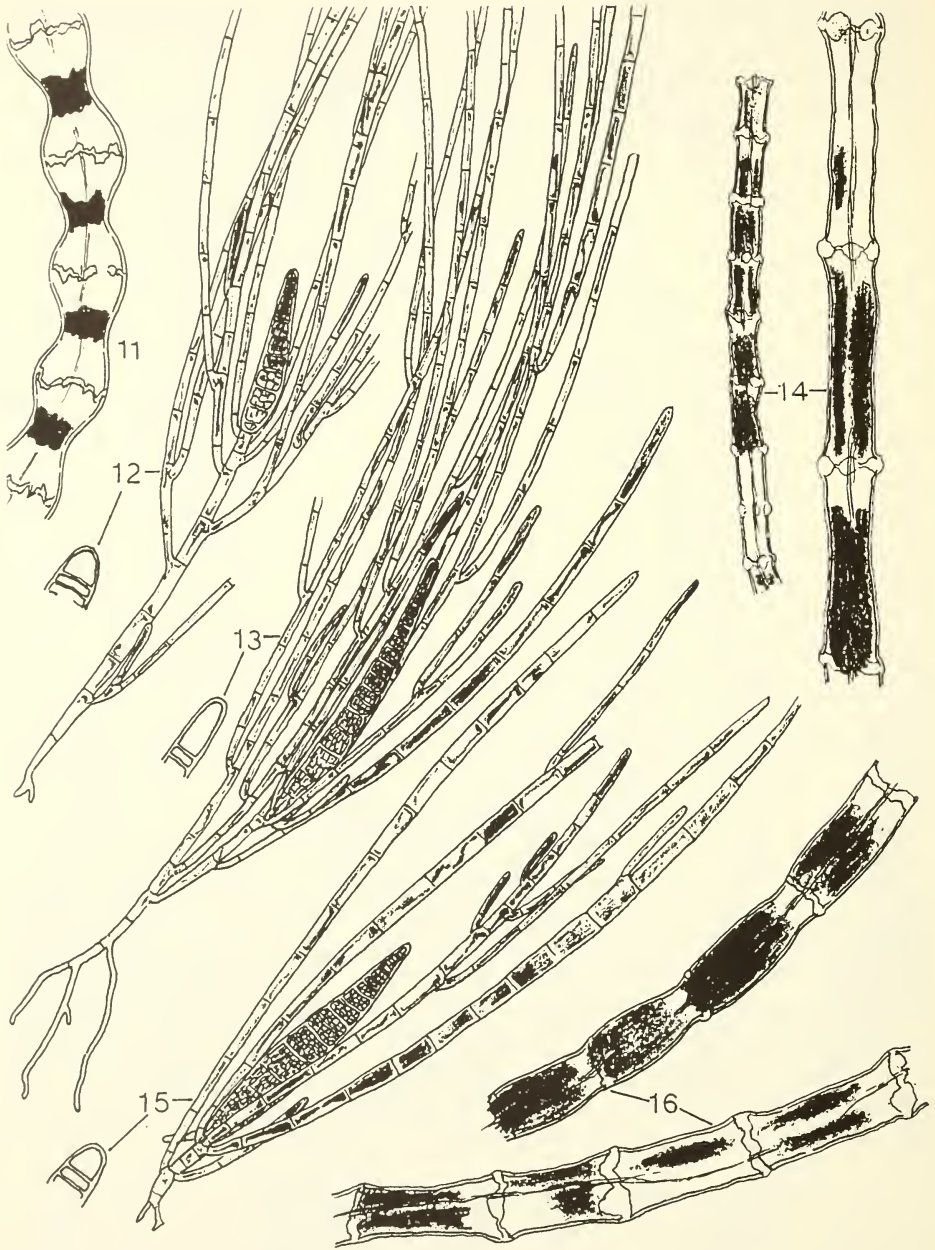
SPECIES DESCRIPTIONS

Five new species of *Paralemanea* from California are described below. These species are based on both herbarium specimens and the author’s collections. Some specimens from the western United States could not be assigned to any one of these five species, but whether these specimens represent hybrids or additional new species will have to await further collecting. All the descriptions are of gametophyte type specimens which have at least a portion of the “chantransia” present. These descriptions are supplemented by observations made on younger or older gametophytic material from other sites or collections. Each description includes measurements of the mature spores from the type specimen.

Paralemanea gardnerii Blum sp. nov.

Figures 5, 6, 20, 21

Axis gametophyti tenuis, internodia ca. 1.0-1.9 mm longa; saepe internodium cylindricis et nodis leviter amplificatis. Filum centrale in parte media thalli e 20-50 rhizoideis corticatis constans. Pars infima spermatangialis (ad primum nodum) ca. 4.3-7.2 mm super basem rhizoidalem. Taenia spermatangialia valde confectis aut annuli raro adsunt vel omnino absunt, sed ab nodo 15+ cum adsunt, ca. 25-90 µm lata, et non latiora distaliter. Multi nodi alveis annularibus non profundis positos quasi cum taeniis spermatangialibus. Cystocarpis plerumque 2-6 per internodium. Aspectus fasciatus typicus cum sporis. Sporae 13.2-28.6 x 15.4-33 µm. Caespites “chantransia” sine filamentis valde conicis aut filamento claro principali. In locis valde caespitosis, filamenta basalia 11-20 µm diametro ad septa.



Figures 11-16. Mature gametophyte axes; "chantransias" each bearing one juvenile gametophyte axis; the apical cell of the juvenile gametophyte of each "chantransia" (Figures 12, 13, and 15) is enlarged at the left (x900). **11.** *Paralemanea brandegeei*, mature gametophyte axis, TYPE (x10). **12.** *P. brandegeei*, "chantransia" (x150). **13.** *P. parishii*, "chantransia" (x150). **14.** *P. parishii*, mature gametophyte axis, TYPE (x10). **15.** *P. tulensis*, "chantransia" (x150). **16.** *P. tulensis*, mature gametophyte axis, TYPE (x10).

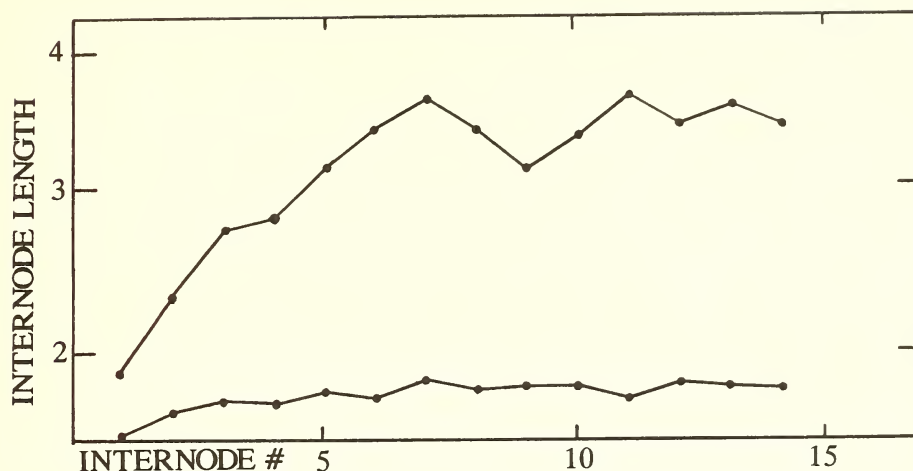


Figure 17. The internode length (mm) of *Paralemanea californica* shown from internode 1 through 14 on the upper line and for *P. gardnerii* on the lower line. The upper line is an average of four collections (7 axes) of *P. californica* (see Figure 18). The lower line is an average of four collections (8 axes) of *P. gardnerii*.

Gametophyte axis slender, often cylindric; internodes mostly 1.0-1.9 mm in length, sometimes with gently swollen nodes; central strand in the mesothallus of ca. 10-30 corticating rhizoids. Lowest spermatangial area (at node 1) ca. 4.3-7.2 mm above the rhizoidal base but with ostensibly complete annular bands or rings starting only at node 15 or higher; the annular bands ca. 25-90 μ m in width, not increasing in overall width on superior nodes; many nodes showing shallow annular troughs approximately coinciding in position with the spermatangial bands. Cystocarps usually 2-6 per internode; banded appearance typical, if spores are present. Spores ca. 13-31 x 19-42 μ m. "Chantransia" without markedly conical filaments, but sometimes with an identifiable main filament wider than the primary branches; the basal filaments 13-26 μ m in diameter at the crosswalls, branch filaments 13-17 μ m.

Type. San Francisquito Creek, Santa Clara County, California, no date, *N.L. Gardner* 2846 (UC 27167).

Additional Collections. Palm Canyon, Borrego Valley, San Diego County, California, May 4, 1929, *F.R. Fosberg* (UC); Mill Valley, Marin County, California, July 20, 1906, *N.L. Gardner* 1792 (UC 94471, 276168); Mt. Tamalpais, Marin County, July 1906, *W.J.V. Osterhout* (UC 94470); Mill Creek, Marin County, California, July 18, 1925, *H.E. Parks* (UC 278342); Mill Creek, Marin County, California, July 1925, *W.A. and C.B. Setchell* (MO in UC 1018388).

Description. The type material has a few young gametophyte axes and was chosen partly for this reason. The other collections listed above include the type material of *Lemanea annulata* var. *franciscana* Atkinson (*Bot. Gaz.* 92(2): 232, 1931). There are parallels between *Paralemanea californica* and *P. gardnerii*,

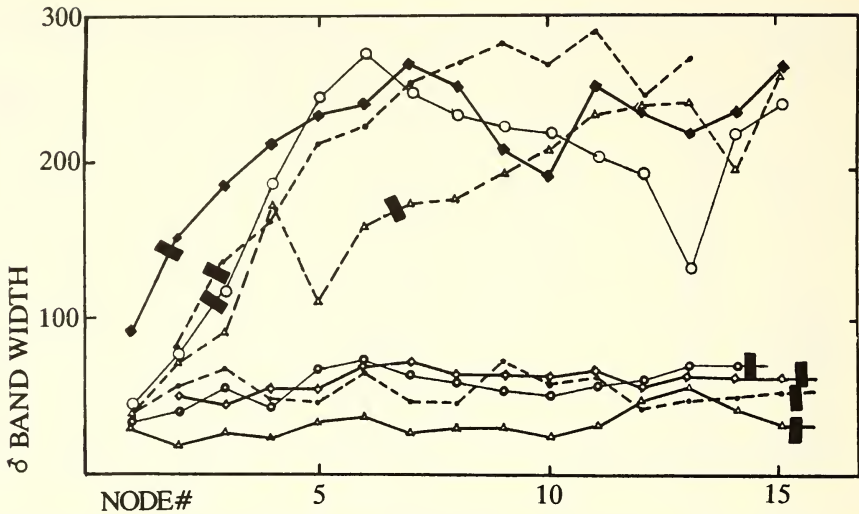


Figure 18. The width of the spermatangial band (μm) and the point at which it becomes complete are contrasted for *Paralemanea californica* (the four upper lines) and *P. gardnerii* (the four lower lines). The upper four lines show band width from node 1 through node 15 in *P. californica*; the heavy black bar indicates where on the axes the first complete nodes were recorded. The collections of *P. californica* represented are from: C.C. Parry, Santa Margarita (diamonds, heavy line; $n = 2$; CU); Blasdale collection (circles, light line; $n = 2$; UC); G.W. Hollenberg, 179 (dots, broken line; $n = 1$; US); R.S. Ferris and R. Bacigalupi, TYPE (triangles, broken line; $n = 2$; UC). The lower four lines show band width from node 1 through node 15 in *P. gardnerii*; the heavy black bars terminating the record indicate that complete bands were not recorded in this region of the axis (nodes 1-15), although higher nodes might have complete bands. The collections of *P. gardnerii* represented are from: N.L. Gardner, 2846, TYPE (dots, broken line; $n = 2$; UC); Osterhout collection (circles, narrow line; $n = 2$; US); Fosberg collection (diamonds, heavy line; $n = 2$; UC); Parks collection (triangles, heavy line; $n = 2$; UC).

thus the transfer of the varietal name *franciscana* to *P. californica* was considered. However, the nature of the juvenile gametophytes and of the spermatangial bands led to the conclusion that this transfer was unwise, and a new specific name is proposed.

Some of the collections had usable "chantransia" material, but the type appears to be the only collection having juvenile gametophytes on the "chantransia." Several of the collections are from the area of Mill Valley and may represent multiple samplings of a single population.

Paralemanea gardnerii shares with *P. californica* sp. nov. the occasional occurrence of a nodal trough (see below) and appears superficially to be a smaller and near-cylindric version of the latter. The narrower spermatangial band and the persistence of spotlike spermatangial areas and/or broken or incomplete bands

throughout much of the axis delimit *P. gardnerii* from *P. californica*. The tendency to show little or no distal increase in the width of the spermatangial band and practically no distal increase in internodal length constitute additional points of distinction. The patches of spermatogenous cells are seldom, if ever, raised above the general epidermal surface as they are in *P. parishii* sp. nov., and they are usually irregular and often angular, rather than rounded. The terminal initials of the young gametophytic axes bear some resemblance to those of *P. californica*; the type collection contains many examples of these, but the terminal initials offer no obvious contrast with *Paralemanea* axes from the eastern United States or Europe.

***Paralemanea californica* Blum sp. nov.**

Figures 7-10, 19

Axis gametophyti robustus. Internodia plerumque 2-4 mm longa, saepe nodis valde tumidis. Filum centrale in parte media thalli e 20-50 rhizoideis corticatis constans. Pars infima spermatangialis (ad primum nodum) circa 2.9-5.4 mm super basem rhizoidalem et ex una vel pluribus maculis spermatangialibus constans, sed taeniis valde confectis aut annulis ab secundo aut tertio (-8) nodo et taeniis annularibus circa 110-300 μ m latis crescentibus distaliter latitudine post nodes spermatangiales 1-7. Multi nodi alveis annularibus non profundis positos quasi cum taeniis spermatangialibus. Cystocarpis plerumque 5-8 per internodium. Massa sporae maturae internodium non replens. Aspectus fasciatus typicus cum sporis. Sporae ca. 13.2-28.6 x 15.4-33 μ m. Caespites "chantransia" in locis valde caespitosis, filamenta basalia 11-20 μ m diametro ad septa. Initia axis juvenis in portionem elongatam et cylindricam distaliter terminantia.

Gametophyte axis robust; internodes mostly 2-4 mm in length, often with clearly swollen nodes; central strand in the mesothallus comprising ca. 20-50 corticating rhizoids. Lowest spermatangial area (at node 1) ca. 2.9-5.4 mm above the rhizoidal base and consisting of one or more spermatophorous spots, but with complete annular bands or rings starting at node 2 or 3 (-8), the annular bands ca. 110-300 μ m in diameter, increasing distally in width after the initial series (nodes 1-7) of spermatangial nodes (Figure 18); many nodes showing shallow annular troughs approximately coinciding in position with the spermatangial bands. Cystocarps usually 5-8 per internode; mature spore mass not filling the internode. Banded appearance typical, if spores are present. Spores ca. 13.2-28.6 x 15.4-33 μ m. "Chantransia" in places heavily tufted; the basal filaments 11-20 μ m in diameter at the crosswalls; branch filaments mostly 11-15 μ m in diameter at the crosswalls. Young axis initials terminating distally in an elongate cylindric portion (Figures 7, 19).

Type. Four miles north of the Ben Hur Post Office, Mariposa County, California. May 29, 1941, *R.S. Ferris* and *R. Bacigalupi* (DS in UC 502456).

Additional Collections. Oakland (no other data), *C.L. Anderson* (Herb. Atkinson) (UC); Santa Cruz, Santa Cruz County, *C.L. Anderson* (FH); Herb. Bolander (no data), *Anonymous* (US); Atlas, Napa County, California, May 1916, *W.C. Blasdale* (UC); Eastern Oregon, 1886, *W.C. Cusick 1353* (CU); Los Troncos Creek, woods near Palo Alto, Santa Clara County, California, 6-1-1932, *G.W. Hollenberg 179* (US); Santa Margarita, San Luis Obispo County, April, 1850, *C.C. Parry* (CU); Little Carson Canyon, Sonoma County, California, March

1917, *L.P. Rose* (UC); Japocha Springs, Cuyamaca Mountains, San Diego County, California, May 26, 1978, *J. Stewart 3318a* (LAM).

Description. The type was chosen because the collection included both juvenile and mature gametophyte material, spores, and "chantransia." Of the above collections, the Blasdale collection shows the general structure of the gametophyte the best, and the anonymous collection from the Bolander Herbarium (in US) shows the juvenile gametophyte axes the best. An additional collection (W.I. and E.B. Follett) from Seigler Canyon, Lake County, California (see below) is questionably referable to this species.

Paralemanea californica is one of the larger and more graceful species of the genus in North America. The large gametophyte axes, up to 15 cm or more in length and 1-2 mm in nodal diameter, are likely to be mixed with narrower and shorter axes. The elongate internodes and the obviously banded appearance, when spores are present, are characteristic of *P. californica*. Fresh material was not available, but for much of the herbarium material examined (largely early and mid-summer collections), the mass of maturing spores forms a mid-internodal plug, which is confined to a small portion of the internodal midsection. The spore mass is further constricted by the axis wall, which is, and apparently remains, narrowest at this approximate midpoint of the internode (Figure 9). Whereas substantial inflation of the nodes is typical, a slight depression (trough) often occurs at the midpoint (of the inflated area), which may, as in *P. gardnerii*, completely encircle the node (Figure 21). This trough usually corresponds with the area occupied in whole or in part by the spermatangial band.

Paralemanea californica is set off from other California species by its substantial internode length and by the increase in length of successive internodes, especially from spermatangial node 1 through 3 (Figure 17). *Paralemanea gardnerii* shows only a slight increase in internode length in this area (Figure 17).

A broad spermatangial annulus is characteristic of *P. californica*. The annulus is regularly present as a complete ring, starting at about spermatangial node 2 or 3 (Figure 18) and continuing to the distal end of the axis. Apart from the inflation of the entire nodal area, little or no elevation of the spermatangial sorus occurs above the epidermal level. The basal node bears 1-3 spermatangial sori.

The most pronounced morphological peculiarity of *Paralemanea californica* is the proboscoïd distal end of the young gametophyte at about the 300-800 cell stage. A terminal uniseriate cylinder below the apical cell is typical, consisting of 10-20 cells which are undivided periaxially, the entire uniseriate cylinder remaining for a time narrower than the remainder of the axis. In all the collections of *P. californica* studied, the elongate uniseriate tip appears to be a temporary phenomenon that is absent from juvenile gametophytes which have attained about 2 cm in length.

Paralemanea brandegeei Blum sp. nov.

Figures 11, 12, 22

Axis gametophyti robustus. Internodia plerumque 2-3 mm longa, saepe nodis valde tumidis. Filum centrale in parte media thalli e 30-40 rhizoideis corticatis constans. Pars infima spermatangialis (ad primum nodum) ca. 6-8.5 mm super basem rhizoidalem et ex una vel pluribus maculis spermatangiales constans; sed taeniis valde confectis aut annulis ab sexto (-9) nodo et taeniis annularibus ca. 80-150 μ m latis crescentibus

distaliter latitudine post nodes spermatangiales 1-7. Cystocarpia plerumque 5-8 per internodium. Massa sporae maturae internodium non replens. Aspectus fasciatus typicus cum sporis. Sporae 15.4-24.2 x 17.6-30 μ m. Caespites chantransiae flabelliformes; rami principales altiores e stipite basali 4-10 cellularum plerumque exorientes; rami usque ad 28 μ m diametro. Initia in chantransia gametophyti basalia aut comparate alta; cellula apicalis tholiformis.

Gametophyte axis robust, internodes mostly 2-3 mm in length with swollen, frequently inflated nodes; central strand in the mesothallus comprising ca. 30-40 corticating rhizoids; lowest spermatangial area (at node 1) ca. 6-8.5 mm above the rhizoidal base and consisting of one or more spermatophorous spots, but with complete annular bands or rings starting at about nodes 6-9; the annular bands ca. 80-150 μ m in diameter, increasing distally in width after the initial series (nodes 1-7) of spermatangial nodes. Cystocarps usually 5-8 per internode; mature spore mass not filling the internode; banded appearance is typical, if spores are present. Spores 15.4-24.2 x 17.6-30 μ m. "Chantransia" tufts without markedly conical filaments when reproductive, but sometimes with a main filament wider than the primary branches. Young axis initials without an elongate cylindric portion; apical cell dome-shaped.

Type. This species is known only from the type locality: New York River, Eldorado County, California, May 10, 1945(?), Mrs. Katherine Brandegee (UC 277581).

Supplementary Type (for "chantransia"). Same locale as above, December 12, 1993, *J.L. Blum* 5179.

Additional Collections. New York Ravine, Eldorado County, California, May 1907, Mrs. L.S. Brandegee (UC 447018); Same locale, September 17, 1988, *J.L. Blum* 4948; Same locale, July 29, 1990, *J.L. Blum* 5056; Same locale, March 10, 1991, *J.L. Blum* 5076.

Description. All of these collections except for the supplementary type were essentially devoid of juvenile gametophytes and included little "chantransia" material. The mature gametophyte of *Paralemanea brandegeei* has much shorter internodes than *P. californica*, but it was tentatively considered to be a form of the latter species until the December 1993 collection, when the locale yielded abundant "chantransia" with juvenile gametophytes, which were very different from those of *P. californica*. The dome-shaped apical cell is similar in shape to most *Paralemanea* apical cells, but the more mature gametophyte, because of its relatively short internodes and "banded" appearance, is unlike any other North American *Paralemanea* that the author has observed.

Paralemanea parishii Blum sp. nov.

Figures 13, 14, 23

Axis gametophyti tenuis et nodosus, saepe internodis cylindricis et nodis leviter amplificatis. Internodia ca. 1.0-1.5 mm longa. Filum centrale in parte media thalli ex rhizoideis 5-22 corticatis constans. Cystocarpis plerumque 2-6 per internodium. Massa sporae maturae paene internodium replens. Pars infima spermatangialis (ad primum nodum) ca (4.8-) 6.7-9.4 mm super basem rhizoidalem et ex una aut pluribus maculis rotundis elevatisque constans, interdum per 15 aut plures nodos saepe extendens. Sporae 11-20 x 15-31 μ m. Caespites "chantransia" sine filamentis valde conicis, interdum filamento claro principali quod latius est quam rami principales. Filamentum principale 19-22 μ m diametro ad septa. Rami 14-19 μ m diametro ad septa. Cellula apicalis gametophyti cylindrica.

Gametophyte axis narrow and nodose, often with cylindric internodes and slightly enlarged nodes. Internodes mostly 1.0-1.5 mm in length, the central strand in the mesothallus comprising 5-22 corticating rhizoids. Cystocarps 2-7 per internode. Mature spore mass filling the internode. Spermatangial areas beginning (node 1) with one or more rounded and raised spots at (4.8-) 6.7-9.4 mm above the rhizoidal base, this pattern of spots sometimes continuing distally for 15 or more nodes; the sequent spermatangial bands, ca. 50-100 μm in width, not increasing materially in width distally. Spores 11-20 x 15-31 μm . "Chantransia" without markedly conical filaments but sometimes with an identifiable main filament wider than the principal branches. Main filament 19-22 μm in diameter, its branches 14-19 μm in diameter. Apical cell cylindric.

Type. Tahquitz Creek about 0.6 km below Tahquitz Falls, Palm Springs, Riverside County, California, December 9, 1993, *J.L. Blum 5175* (UC).

Additional Collections. West Cañon at Palm Springs, 1-10 April 1896, *S.B. Parish 4055* (UC 205366); In hills 2 miles southwest of Bloomington in the vicinity of San Bernardino, San Bernardino County, California, March 23, 1897, *S.B. Parish* (UC 94473).

Description. The author's attention was directed to the Tahquitz area (formerly called West Cañon at Palm Springs) by S.R. Parish's collections there nearly a century ago. My collections include both "chantransia" and gametophyte material, including juvenile material, which appears to be totally lacking in Parish's collections.

Parish's locality near San Bernardino could not be located with precision. Both of Parish's collections consist of relatively small gametophyte axes with cylindric internodes. The nodes, as in the Tahquitz Creek material, tend to be enlarged, producing an axis which can be compared to a knotted cord with considerable space between the knots. The axes are further characterized by raised spermatangial areas, which may appear as circular mounds, frequently four in number, at a node. The mounds may be separate from each other, at least in the first fifteen nodes, or joined by narrow connections. The presence of spermatangial areas is suggestive of the spermatangial protuberances in *Lemanea* (as opposed to *Paralemanea*), but usually these areas are less pronounced and, in the mesothallus, tend to become somewhat fused. No significant increase in spermatangial band width or internode length occurs within the mesothallus, and the spermatangial band appears as a broken ring at many of the lower nodes. The number of cystocarps is 2-7 per node, but 2 appears to be the most common number (which is often the case in relatively narrow *Paralemanea* axes). The species characteristically shows considerable size variation in the gametophyte axes. In the mature gametophyte, the spore mass fills much of the internode and sometimes extends proximally, thus occupying much of the subtending nodal area as well.

The "chantransia" filaments are narrower and longer than in the other California species, and they often bear the juvenile gametophytes a short distance (4.5 mm) above the rhizoidal base. The apical cell of the young gametophyte is greatly elongated in comparison with the apical cells of the other species.

***Paralemanea tulensis* Blum sp. nov.**

Figures 15, 16

Axis gametophyti cellulis epidermicis comparate parvis quorum 170-210 transectum 1 mm scindunt. Axis leviter nodosus internodiis, diameter axis, ubi repletus sporis, diametrum nodi frequent superans. Internodia ca. 1.0-1.8 mm longa. Filum centrale in parte mesothalli ex rhizoideis 20-30 corticatis constans. Pars infima spermatangialis (ad primum nodum) ca. 4.3-7.2 mm super basem rhizoidalem, taeniis annularibus valde confectis aut annulis ad nodes distales ab nodes 3-5. Taenia annularia spermatangialis ca. 85-230 μ m late, valde latiora a nodo 3 distaliter. Massa sporae maturae paene internodium replens. Sporae ca. 8-24 x 15-31 μ m. "Chantransia" filamenta valde conica, includens quae distaliter amplificant ab 13 usque ad 33 μ m. Cellula apicalis tholiformis.

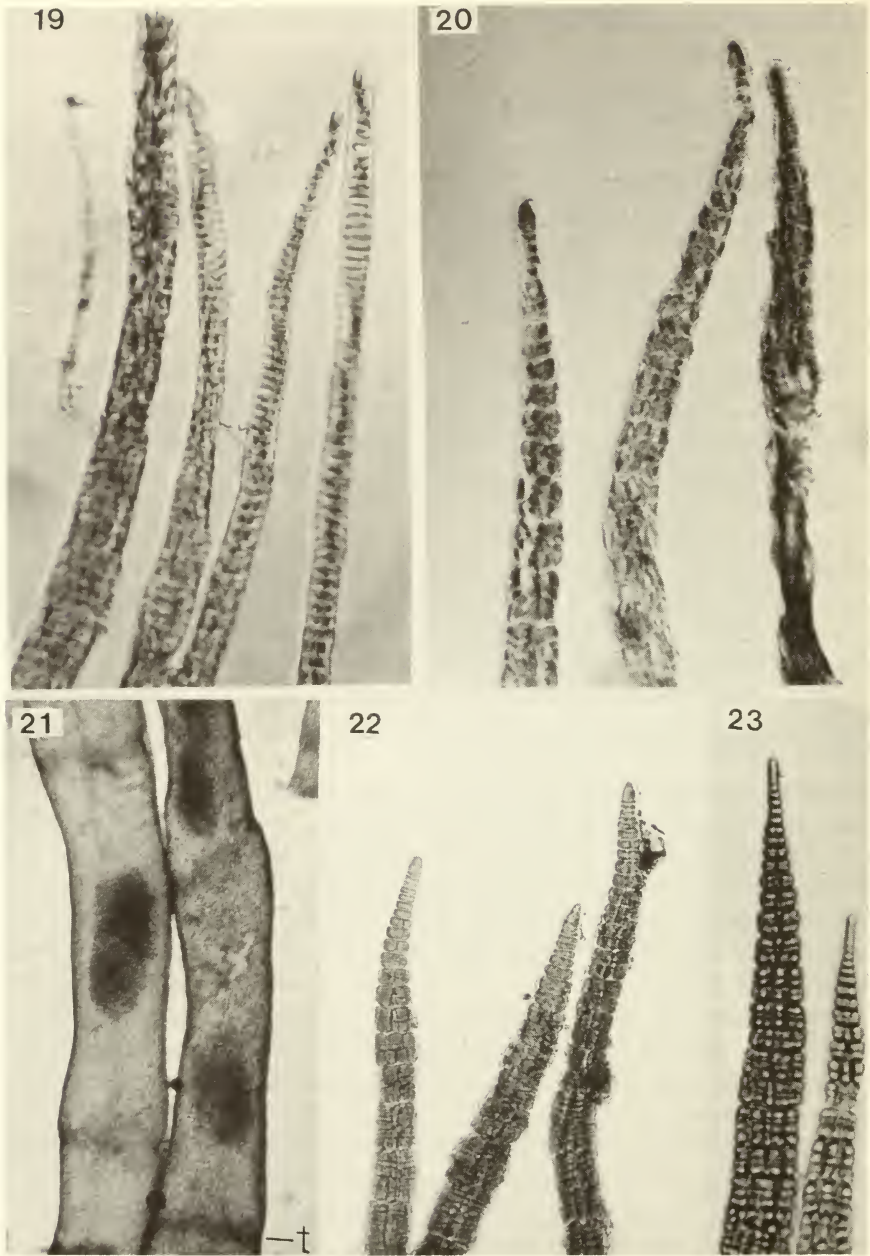
Gametophyte axis with relatively small epidermal cells of which 170-210 occur on a 1 mm transect; slightly nodose with internodes, where spore-filled, frequently exceeding in diameter the nodal diameter. Internodes ca. 1.0-1.8 mm in length. Central strand in the mesothallus comprising ca. 20-30 corticating rhizoids. Lowest spermatangial area (node 1) ca. 4.3-7.2 mm above the rhizoidal base but with ostensibly complete annular bands or rings at the nodes distally from nodes 3-5; the annular bands showing a substantial increase in width from node 3 distally. Mature spore mass approximately filling the internode. Spores ca. 8-24 x 15-31 μ m. "Chantransia" with markedly conical filaments which enlarge distally from 13-33 μ m. Apical cell dome-shaped.

Tape. North Fork of the Tule River on large rocks at the crossing of Highway 190, Springville, Tulare County, California, December 11, 1993, *J.L. Blum 5176* (UC).

Additional Collections. On rocks in the Tule River, Burnett Park, east of Porterville, Tulare County, California, October 5, 1941, *F. Drouet and M.J. Groesbeck 4502* (MICH 20707); In the North Fork of Tule River above Springville, Tulare County, California, September 20, 1988, *J.L. Blum 4963* (UC); Same locale, July 28, 1990, *J.L. Blum 5054* (UC); In the Tule River above Springville, Tulare County, California, June 15, 1985, *J. Stewart 4514-a* (in the author's collection).

Description. To date, *Paralemanea tulensis* is known only from the Tule River in the area of Springville and Porterville, Tulare County, California. *Paralemanea tulensis* is a form of intermediate size with a clearly banded appearance at maturity. Its spores, by their growth, often enlarge the internode to such a degree that its diameter frequently or even regularly exceeds the nodal diameter, contrary to the usual relationship in *Paralemanea* (nodes larger than the internodes). This species is the only *Paralemanea* species encountered which shows this phenomenon regularly, although an occasional internode in other collections may approximate this condition. The spermatangial areas of *P. tulensis* form complete rings from node 3-5 on and show a slight but steady increase in width from node 1 through node 10. A similar increase in internode length is also typical (as in *P. californica*, Figure 17), but the internodes are in general much shorter than in *P. californica*.

Cystocarp number in *Paralemanea tulensis* has not been determined, as none of the extant material is of an appropriate maturity to show this. The spore mass enlarges longitudinally as well as laterally and, while remaining cohesive, pushes



Figures 19-23. **19.** *Paralentanea californica*, juvenile gametophytic axis (tips) at about the 800 cell stage; the tip of the left axis in the photograph is broken off; H.N. Bolander Herbarium, "California" (x300; US). **20.** *P. gardnerii*, juvenile gametophytic axis tips (x300), N.L. Gardner, 2846, TYPE. **21.** *P. gardnerii*, gametophytic axes (x17; t = trough); Setchell collection (UC). **22.** *P. brandegeei*, juvenile gametophytic axis (tips x200); Blum collection, 5179 (UC). **23.** *P. parishii*, juvenile gametophytic axis (tips; x175); Blum collection, 5175, TYPE (UC).

past the subtending node and into the subjacent internode. Thus, for a time (as in *P. parishii*), the axis shows the remains of the spermatangial band from the internode above on the proximal flank of the spore mass (Figures 14, 16). As in other relatively small *Paralemanea*s, the growth of the gonimoblasts and the form of the spore mass is linear and shows the restraining effect of the narrowly cylindrical thallus wall.

The "chantransia" of *Paralemanea tulensis* is characterized by occasional fusiform filaments, frequently one per tuft of the "chantransia." These filaments widen to a diameter of 30-33 μm in their middle portion. The terminal (narrower) portion is soon lost as a result of molar forces, so the result is an apparently tapered filament, narrower toward its base. The initials of the juvenile gametophytes are formed almost entirely at the base of the "chantransia" tuft.

DISCUSSION

For some time, a need for additional characters has existed by which the division of the genus (*Paralemanea*) as well as the species of long standing could be judged. Hopefully, the new characters, both of the gametophyte and the spores, introduced in this paper will help remedy this need. These new characters allow the identification of the California species, and their utilization for populations from the eastern United States and Europe may make it possible to work out the relationships of these species with greater success.

The decisive contrasts between the California species as a whole and those of the eastern United States (Table 1) may appear to be based on rather insignificant characters. This appearance is misleading for three reasons: 1) researchers are unfamiliar with the characters because they are not the ones customarily used in *Paralemanea* taxonomy; 2) the characters are microscopic in contrast to those upon which the classification schemes of the last 150 years have been based; and 3) they call into question the historic approbation which has been accorded the external form of the gametophyte axis as a basis for classification. The new characters are based largely on the gametophyte; the characteristics of the "chantransia" are not stressed. Although abundant in many collections, the California "chantransias" were not taxonomically useful in most extant collections, because so few gametophyte initials were found.

When the California species as a whole were compared with the European species, the same decisive contrasts, except for spore size, apply. While some European collections were similar to the California material in the distance separating the lowest spermatangial area from the axis base, and others were similar in the number of corticating rhizoids, none of the European species agreed with the California species in both these characters.

Existing descriptions of and keys to *Paralemanea* species rely heavily on the size and shape of the gametophyte, but they are imprecise when describing nodal shape and other features. The author attempted to remedy this situation (Blum, 1993) by developing a series of comparative nodal diagrams. The variability of most *Paralemanea* axes and populations requires the use of abundant material, if meaningful identifications are to be made. Lack of material is the gravest drawback in the use of the type specimens from the 19th century in the genus *Lemanea* (*sensu* 1900). Most of these types consist of only a few axes, and

curatorial responsibility implies that they not be sacrificed. Yet the characters advanced in this paper require the sectioning and mounting of enough material to allow precise descriptions to be prepared and appropriate measurements to be taken. Another drawback is the lack of collection dates for most of the older type specimens. The existing herbarium material for *Paralemanea* is potentially a valuable resource, type specimen or not, but if the collection represents only one day out of the entire growing season, and if no follow-up specimens were taken, the collection's value is greatly reduced. Spring collections from the North Temperate Zone regularly show the young sexual axis, which may still have a portion of the "chantransia" at the base, but virtually none of these collections are supplemented by additional material from the same population obtained later in the year or early in the following year. For an undated specimen, an intelligent guess can be made as to the time of year the collection was made, but even then, such a sample, collected on a single visit to the habitat stream, can yield no information on characters which have not yet appeared in ontogenetic development, or which have already passed. Detailed comparison with a freshly collected specimen, even a dried one of greater or lesser maturity, is really impossible, and on this the naming process founders.

Fully as serious a flaw with the older types is the virtual absence of spore characters. Spore characters (measurements) have been shown to have geographic implications in this paper. That geographic localization, spore size, and other morphological characters show consistency in the California populations implies that these populations are genetically isolated, but the possibility remains that a cline in spore size may be found that is related to different weather and/or other environmental patterns.

The general variability in important characters and the possibility of hybridization are factors that should be studied when working with the California representatives of this group. *Paralemanea californica* and *P. gardnerii* are readily separable on a variety of characters, but at least one collection (W.I. and E.B. Follett, Seigler Canyon Creek, Lake County, California, April 17, 1961 (UC wet stacks)) seems intermediate. The width of the spermatangial band and the presence of complete spermatangial bands starting from low nodes (nodes 2-3) is in disagreement with both the type and other collections of *P. californica*. The only intact juvenile gametophytic axis found in the Follett collection had a terminal uniseriate cylinder as in *P. californica*; this, along with an increase in internode length relative to distance from the base (which this collection shows), led the author to identify it as *P. californica*.

Paralemanea gardnerii is basically cylindric, whereas *P. californica* is clearly nodose. Nevertheless, an affinity between these two species is apparent. They share the presence of a nodal trough, and the more nodose specimens of *P. gardnerii* suggest the outline of some *P. californica* specimens. Whereas the proboscoïd initials of the young gametophyte axes of *P. californica* are unmistakable, a somewhat similar terminus occurs in *P. gardnerii* but is not so marked. A five- to ten-celled uniseriate initial filament is normal in *P. gardnerii* (and in other species of *Paralemanea*).

Both *Paralemanea californica* and *P. gardnerii* have a substantial and wide geographic base in existing collections, but *P. brandegeei*, *P. tulensis*, and *P.*

parishii are much more limited. Additional collections of these taxa may yield some surprises requiring emendations of the species descriptions.

The descriptive characters utilized by Sirodot (1872) in his detailed and careful work on the "chantransia" generation of *Lemanea* included the following: 1) the presence or absence of a principal filament to which the other (branch) filaments are inferior in diameter; 2) unilateral and opposite branching; 3) branching basal on the main filament as against suprabasal; 4) position (high to low) of the young gametophytic axis on the filamentous system; and 5) position of the young gametophyte axes with respect to the supporting filaments (terminal to lateral). A sixth character can be added to these: the tendency of individual filaments to exhibit enlargement toward their tips, a phenomenon noted in the description of the American species, *Lemanea australis* Atkinson (1890).

These characters are best applied to material having young and vigorous "chantransias," but even so, when applied to individual California collections, these characters seldom permit easy identification. The presence of a principal filament is a character apparently offering little opportunity for error. Measurements and averaging, at least for the American material, is necessary to demonstrate the presence of a principal filament. The difference in diameter is slight, and primary branches regularly replace the primary filament, when it is damaged or broken, often equaling or surpassing it in length or diameter.

Where the gametophyte initials develop (i.e., their position relative to the main axis, if any, and the branches of the "chantransia") is considered a significant feature by Sirodot (1872). This character gave mixed results in nearly all the American material studied. Most gametophyte initials are basal on the "chantransia," but in some specimens, these initials can be found at higher levels. In herbarium material, their numbers are so low that no convincing assessment can be made as to their comparative position. Characters based on unilateral branching of the "chantransia," opposite and alternate branching, and basal branching of the main filament as opposed to suprabasal branching are equally dubious.

The "chantransia" characters discussed here may prove difficult to work with. Those collections made and studied by the author in December 1993 were in active growth, good condition, and bore relatively abundant juvenile gametophytes, but workers, who study *Paralemanea* "chantransias" from herbarium material, must reckon with the possibility of substantial modification in structure and appearance due to seasonal and/or other factors. Few extant herbarium specimens of the "chantransia" were in a state of active growth when collected, and few show abundant gametophytic initials. This unfortunately applies to the type material of *P. californica* and *P. gardnerii*. "Banding" is essentially a macroscopic character, which appears as a striking feature only in material from the Pacific seaboard of the United States. European material with relatively faint banding has been found in a few collections, mainly from southern Europe. The European material has all been disqualified on other grounds from conspecificity with the California material.

CONCLUSIONS

Three conclusions emerge from the study of the California species of *Paralemanea*. First, the California species of *Paralemanea* are structurally

distinct from both the species of Europe and the eastern United States. Hence, names applied to the species from Europe and the eastern United States are not applicable to the California material. Second, five species of *Paralemanea* are named and described. These species are based on specimens from California, and their diagnoses utilize morphological characteristics not previously used in the taxonomy of this family (Lemaneaceae). Finally, the descriptions of new species of *Paralemanea* should be based on more than one collection. Ideally, the collections should include both the young and mature gametophytes, mature carpospores, and young "chantransias." Unfortunately, few, if any, of the temperate-zone species named prior to 1890 meet this criterion of adequacy.

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EFFECTS OF A PRESCRIBED BURN ON TREE- AND HERB-LAYER VEGETATION IN A POST OAK (*QUERCUS STELLATA*) DOMINATED FLATWOODS

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ABSTRACT: Post oak flatwoods are an unusual plant community type dominated by even-aged and uniformly sized post oaks (*Quercus stellata*) growing along level terraces of the Ohio River. Historical evidence exists that fire may play a role in the maintenance of the open canopy and poorly-developed understory characteristic of this community type (Dolan and Menges, 1989). The results of summer vegetation surveys taken yearly from 1989 to 1992 in a post oak flatwoods in southwestern Indiana that was subjected to a prescribed burn in the spring of 1989 are reported in this paper. The objective of the study was to determine the effects of the burn on tree- and herb-layer vegetation. The fire killed or top-killed more than half the trees but did not markedly shift the rank order of species importance values. Mortality was greatest among small tree species, such as winged elm and shingle-bark oak, and least among post oak. Composition of the herb-layer did not change greatly following the fire, but several new species were found that did not occur in unburned control plots. The results indicate that fire contributes to the unusual species composition and community structure of post oak flatwoods.

KEYWORDS: Plant community types, post oak flatwoods, prescribed burn.

INTRODUCTION

Historical evidence suggests that fire may play a role in the maintenance of post oak flatwoods, a rare and little-studied forest type (Dolan and Menges, 1989), as it does in post oak savannas where cessation of fire and overgrazing have contributed to the invasion of shrubs and non-native grasses (Scifres, 1982). Post oak (*Quercus stellata*) dominated flatwoods are forests of even-aged and uniformly-sized trees found along level alluvial lacustrine terraces of the Ohio River in southern Indiana and Illinois. They are associated with the McGary silt loam soil type, which has nearly impervious subsoil layers (often a fragipan) that result in ponding in small depressions in the spring and very dry conditions in the summer. The tree layer is dominated by slow-growing post oaks and hickories. These communities lack a well-developed shrub layer. The herbaceous layer is dominated by grasses, sedges, and mosses.

The effects of a prescribed burn on herb- and tree-layer vegetation in a post oak flatwoods community in southwestern Indiana are reported in this paper. The goal of the study was to document tree mortality and to measure the effects of fire on species composition three years following the burn.

Table 1. Mortality and resprouting of tree species following the 1989 prescribed burn.

Species	Pre-Burn No. of Trees	Percent Alive (Live Crowns)	Percent Alive (Resprouting)	Percent Dead
<i>Carya</i> spp.	58	46.6	15.5	37.9
<i>Quercus stellata</i>	51	68.6	5.9	25.5
<i>Q. falcata pagoda</i>	21	47.6	28.6	23.8
<i>Q. imbricaria</i>	17	41.2	29.4	29.4
<i>Q. rubra</i>	17	29.4	23.5	47.1
<i>Ulmus alata</i>	15	33.1	20.2	46.7
<i>U. americana</i>	7	14.2	42.9	42.9
<i>Quercus alba</i>	5	40.0	20.0	40.0
<i>Fraxinus americana</i>	4	-	-	100.0
<i>Nyssa sylvatica</i>	3	33.3	33.3	33.3
<i>Quercus marilandica</i>	3	-	-	100.0
<i>Q. palustris</i>	2	100.0	-	-
<i>Fraxinus</i> sp.	2	100.0	-	-
<i>Liquidambar styraciflua</i>	1	-	100.0	-

MATERIALS AND METHODS

The study was conducted at the Indiana Department of Natural Resources Division of Nature Preserves' 120 acre Post Oak Barrens Nature Preserve (POB) in Spencer County, Indiana (38°06'N, 87°01'W). The vegetation and environment at the site are described in detail in Dolan and Menges (1989).

The current study utilized a permanently marked, 32-point 8 x 4 rectangle of grid points located 25 m apart that was established in 1986 during the initial vegetation survey work at POB. Data from the previous vegetation study (collected in June 1986) were analyzed using two-way indicator species analysis (TWINSPAN; Gauch and Whittaker, 1981) calculated using PC-ORD software (McCune, 1991) to identify plots containing similar herbaceous vegetation. Using this information, the 8 x 4 center point grid system was divided in half geographically, yielding 15 and 17 grid points within the southern and northern portions, respectively. Each half contained vegetation similar to the other. The area containing the southern 15 points was not burned and was used to track changes in species composition in the absence of fire.

The area containing the northern 17 points was subjected to a prescribed burn in April 1989. This burn was conducted in the spring because a fire-crew was available to work at this remote site and because buds were dormant and the leaf litter was dry at this time. A fast-burning surface fire developed with average flame lengths of 50 cm. Dried leaves on top of the litter were burned, but lower sections of the litter remained moist, and the fire did not burn these layers (Chris Maron, pers. comm.).

Data on herb-layer species were gathered from all 32 grid points during the four summers following the April 1989 burn. Cover estimates were made for each species of vascular plant (stems 1 cm dbh), moss, and lichen within 10 m² circular plots (1.79 m radius) centered on the grid points. Cover was estimated in equal angular (arcsine square root) classes (1-7%, 8-25%, 26-50%, 51-75%, 76-93%, 94-100%; Dolan and

Menges, 1989). Species nomenclature follows Gleason and Cronquist (1991). Hickory species (*Carya laciniosa*, *C. ovata*, and *C. tomentosa*) are grouped together because many apparent hybrids were seen and the species are especially difficult to distinguish in the seedling and sapling stage. Young oaks that could not be identified to species were likewise lumped as *Quercus* spp.

The tree layer vegetation was compared before and after the burn by utilizing the 1986 survey as pre-burn data and resampling the trees three years post-burn in 1992. The data gathered were the species name and diameter at breast height (dbh) for all stems larger than 1 cm within circular plots 5.64 m in radius (100 m²) centered on each grid point. Stem sprouts from the same individual were added together to yield total dbh.

Community structure and diversity measurements were calculated for the tree- and herb-layer data using PC-ORD software (McCune, 1991). Surveys of the tree-layer vegetation were conducted in the summers of 1986 and 1992. Surveys of the herb-layer vegetation were conducted each summer from 1986 to 1992. Pre-burn herb-layer diversity data from the 1988 survey, the survey conducted the summer prior to the burn, were compared to post-burn surveys to identify any vegetational changes occurring following the burn.

RESULTS

Tree-Layer Mortality and Resprouting on Burned Plots. Less than half (39.6%) of the trees survived the fire with live crowns; 37.6% of the trees were dead (no evidence of resprouting) three years after the burn. *Quercus stellata*, *Q. pagoda*, and *Q. imbricaria* had the lowest levels of mortality, while *Fraxinus americana*, *Ulmus alata*, *U. americana*, *Quercus rubra*, and *Q. marilandica* were among the highest (Table 1). Seventeen point five percent (17.5%) of the trees were resprouting from the base. *Quercus pagoda*, *Q. imbricaria*, and *Ulmus americana* had the largest numbers of resprouts. Hickories (*Carya* spp.) were more common than post oak in terms of total number of stems and had intermediate levels, relative to the other species, of mortality and resprouting after the fire. Mortality on control plots over the period was 12.0%.

Tree-Layer Stand Structure and Diversity on Burned Plots. Three years following the burn, stem density in burned plots had decreased by 66.5 %, and basal area had decreased by 7.8% (Table 2). The importance value (IV = mean of relative frequency, relative density, and relative basal area; range = 0 - 100%) of *Quercus stellata* increased 10% between pre- and post-burn sampling. This increase is due to a decrease in IV for all other species except for modest increases in *Quercus pagoda* and *Q. palustris*. Rank order of species by importance value did not change following the burn with the exception of a rise in rank of *Q. palustris*. Species richness was lower on plots following the burn (Table 3), but there were no significant differences in evenness or Shannon-Weaver diversity before and after the burn.

Herb-Layer Composition and Cover for Burned and Unburned Plots. No significant changes in richness or diversity in the herb-layer plots were noted following the burn, but an increase in evenness in species distribution (Table 4) was apparent. The three measures did not change significantly on the unburned plots over the four-year time period.

Table 2. Tree species composition before and after a prescribed burn in 1989.

Species	Pre-Burn (1986)			Post-Burn (1992)		
	Density (Trees/ha)	Basal Area (m ² /ha)	IV* (%)	Density (Trees/ha)	Basal Area (m ² /ha)	IV* (%)
<i>Quercus stellata</i>	340	18.5	41	200	16.9	51
<i>Carya</i> spp.	387	0.5	16	87	0.4	14
<i>Quercus falcata pagoda</i>	140	0.5	9	60	0.5	10
<i>Q. imbricaria</i>	113	0.3	7	33	0.2	6
<i>Q. rubra</i>	113	0.8	7	20	0.7	5
<i>Ulmus alata</i>	100	-	5	20	-	2
<i>Quercus palustris</i>	13	2.2	4	13	2.4	7
<i>Ulmus americana</i>	47	-	3	7	-	1
<i>Quercus alba</i>	33	0.1	3	13	0.1	3
<i>Nyssa sylvatica</i>	20	-	1	7	-	1
<i>Quercus marilandica</i>	20	-	1	-	-	-
<i>Fraxinus americana</i>	27	-	12	-	-	-
<i>Fraxinus</i> sp.	13	-	1	-	-	-
<i>Liquidambar styraciflua</i>	7	-	1	-	-	-
All species	1373	23.2	100	460	21.4	100

*Importance value = mean of relative density, relative basal area, and relative frequency.

Table 3. Plot-level diversity measures of tree-layer species composition in control and burned plots pre- and post-burn.

	N	Richness	Evenness	H'
Unburned plots - Pre-burn (1986)	17	4.7	0.277	0.444
Unburned plots - Post-burn (1992)	17	5.2	0.277	0.483
Burned plots - Pre-burn (1986)	15	5.3**	0.319	0.561
Burned plots - Post-burn (1992)	15	2.8**	0.367	0.383

* H' = Relativized Shannon-Weaver Index.

** Significantly different at $p < 0.001$ based on paired t -test.

Danthonia spicata was the most frequently encountered species in the herb-layer both before and after the burn (Table 5), followed by *Polytrichum ohioense*, *Quercus* spp. seedlings, *Toxicodendron radicans*, and *Eleocharis tenuis* var. *verrucosa*. Seedlings of *Diospyros virginiana* and the grass, *Agrostis perennans*, were not found on burned plots prior to the burn, but in 1992, both were present in 3 of the 15 burned plots. *Potentilla simplex* and seedlings of *Prunus serotina* and *Quercus imbricaria* were completely eliminated from burned plots and had not reappeared in 1992.

Of the prominent non-vascular plants present, *Polytrichum ohioense* was more fire-tolerant than *Leucobryum glaucum*, suffering a 20% drop in frequency but maintaining the same average cover class three years following the burn as it had before the burn (Table 5). *Leucobryum glaucum* decreased by half in both

Table 4. Plot-level diversity measures of herb-layer species composition in control and burned plots pre- and post-burn.

	N	Richness	Evenness	H'
Unburned plots - Pre-burn (1988)	17	7.5	0.962	1.877
Unburned plots - Post-burn (1992)	17	7.8	0.964	1.883
Burned plots - Pre-burn (1988)	15	7.1	0.938**	1.818
Burned plots - Post-burn (1992)	15	8.1	0.961**	1.979

* H' =Relativized Shannon-Weaver Index.

**Significantly different at $p < 0.01$ based on paired t -test.

measures. *Cladonia strepsilis*, a lichen, was killed by the fire and had not reestablished in 1992.

Over the three growing seasons following the burn, nine new species were found in the burned plots (Table 6). *Erechtites hieracifolia* (commonly called fire weed) was present in great abundance (average cover class = 0.4) in the first summer after the fire, was present as a few small individuals the second summer (average cover class = 0.07), and was not present in 1991. The grasses, *Panicum dichotomum*, *P. lanuginosum*, and *Agrostis perennans*, were found following the burn, along with *Rhus glabra*. On unburned plots, 5 new species were found during the 4-year survey period. Two of these, *Panicum lanuginosum* and *Agrostis perennans*, were also found on burned plots.

DISCUSSION

The tree data show that the prescribed burn did contribute to the characteristic open understory of post oak flatwoods (Aldrich and Homoya, 1984) by killing and reducing the density of smaller understory trees, such as winged elm (*Ulmus alata*). A secondary effect was an increase in the importance value of the community indicator species, *Quercus stellata*, with no change in the overall rank order of the other tree species present.

Post oak is reportedly a slow-growing tree, often overtopped by other species and intolerant of competition and shade, but able to persist and become dominant on poor sites due to its drought resistance (Fowells, 1965). At POB, environmental features such as low water and nutrient availability, coupled with occasional fire (Aldrich and Homoya, 1984; Dolan and Menges, 1989) appear to keep succession in check, keeping mid-successional oaks dominant.

No evidence exists at POB for replacement of oak with more mesic species, a phenomenon found in other oak forest types in the northeast and central United States where shade-tolerant, mesic species such as sugar maple dominate the understory (Abrams, 1992). Abrams (1992) has stated that "stable late successional oak forests are probably limited to areas at the western extent of the eastern deciduous forest biome or to very xeric, nutrient poor sites further east." As examples, he cites post oak forests derived from savanna in Oklahoma and blackjack oak forests on extremely xeric upland sites in Illinois. Nowacki, *et al.* (1990) support the notion that oak dominated communities are more stable on

Table 5. A comparison of frequency and average cover class of herb-layer vegetation in 15 plots before and after the burn. All species with 10% overall frequency or greater before or after the burn are included.

Species	Pre-Burn (1988)		Post-Burn (1992)	
	% Freq.	Ave. Cover Class	% Freq.	Ave. Cover Class
<i>Danthonia spicata</i>	80.0	1.3	73.7	1.7
<i>Polytrichum ohioense</i> *	60.0	0.9	40.0	0.9
<i>Quercus</i> spp.	53.3	1.1	60.0	1.3
<i>Toxicodendron radicans</i>	46.7	1.2	40.0	1.3
<i>Eleocharis tenuis</i> var. <i>verrucosa</i>	33.3	0.5	46.7	1.0
<i>Leucobryum glaucum</i> *	33.3	0.4	13.3	0.2
<i>Potentilla simplex</i>	16.6	0.6	0.0	0.0
<i>Carex laxiflora</i>	26.6	0.3	20.0	0.3
<i>Luzula echinata</i>	20.0	0.2	13.3	0.1
<i>Parthenocissus quinquefolia</i>	20.0	0.5	26.7	0.5
<i>Viola sagittata</i>	20.0	0.3	6.7	0.1
<i>Quercus imbricaria</i>	20.0	0.3	0.0	0.0
<i>Lysimachia lanceolata</i>	20.0	0.4	20.0	0.3
<i>Panicum depauperatum</i>	13.3	0.1	33.3	0.5
<i>Cladonia strepsilis</i> *	13.3	0.1	0.0	0.0
<i>Carya</i> spp.	13.3	0.3	46.7	1.2
<i>Porteranthus stipulatus</i>	13.3	0.1	33.3	0.5
<i>Carex caroliniana</i>	6.7	0.1	53.3	0.9
<i>Crataegus</i> sp.	0.1	0.1	20.0	0.2
<i>Diospyros virginiana</i>	0.2	0.3	33.3	0.3
<i>Agrostis perennans</i>	0.0	0.0	33.0	0.5

* Non-vascular plant.

xeric sites. The relative stability of these communities is attributed to the ability of upland oaks to resist fire (presumed to have been fairly frequent historically) and drought (through a combination of morphological and physiological adaptations) and the ability to survive on nutrient-poor soils (Abrams, 1992).

Following the fire at POB, subtle shifts occurred in the composition of the vegetation as indicated by a significant decrease in richness in the tree-layer (Table 3) and an increase in evenness in the herb-layer (Table 4) in the absence of significant changes in Shannon-Weaver diversity index values. The presence of *Erechtites hieracifolia* (fire weed) at the site for the first time following the burn (Table 6) indicates that the prescribed burn was sufficiently intense to induce fire-related changes in the vegetation at the site. This annual plant is often found in burned-over woodlands (Deam, 1940). Whether the seeds of fire weed were dispersed into the site or were present in the soil is not known. Also appearing after the burn was the potentially unfavorable species *Rhus glabra*, whose clonal spread can shade out other native species. *Rhus glabra* presents a management problem as a woody invader of glades and hill prairies in Illinois (Hutchinson, 1990) and presumably has the potential to become problematic at POB. *Agrostis perennans*, as the name implies, is a perennial grass of woodlands, often occurring

Table 6. New species appearing in the herb-layer following the 1989 prescribed burn. The year of first observation is in parentheses following the species name. Species were observed in surveys each subsequent year unless indicated.

Burned Plots	Unburned Control Plots
<i>Erechtites hieracifolia</i> (1989, not present in 1991 or 1992)	<i>Acer negundo</i> (1990)
<i>Parietaria pensylvanica</i> (1989)	<i>Agrostis perennans</i> (1991)
<i>Phytolacca americana</i> (1989)	<i>Heuchera</i> sp. (1991)
<i>Urtica</i> sp. (1989)	<i>Viola</i> sp. (1991)
<i>Heuchera</i> sp. (1989)	<i>Panicum lanuginosum</i> (1991)
<i>Panicum dichotomum</i> (1990)	
<i>Panicum lanuginosum</i> (1990)	
<i>Agrostis perennans</i> (1991)	
<i>Rhus glabra</i> (1991)	

on damp soils but sometimes found in dry open woods and adjacent fields (Voss, 1972). It was not encountered at POB in woods or barrens prior to the burn (Dolan and Menges, 1989) and was not seen in previous surveys of adjacent post oak flatwoods (Aldrich and Homoya, 1984). The non-habitat specialist, *Phytolacca americana*, also appeared following the burn but was not recorded in unburned areas.

CONCLUSIONS

Frequency estimates for presettlement fires in fire-adapted communities of eastern North America range from yearly for prairies (Abrams, 1992), to every 4.3 years for post oak savannas in Missouri (Guyette and Cutter, 1991), to 50-100 years for oak forests in the Midwest and eastern United States (Abrams, 1992). Evidence collected at POB based on fire scars detected in tree-ring analysis and on interviews with long-time residents of the area indicate a historical fire frequency of about one fire every 30 years (Dolan and Menges, 1989). The prescribed burn described here killed understory trees but had little impact on plot-level diversity three years following the fire. The reduced competition resulting from fire may be beneficial to the growth of post oak. These benefits may outweigh the slight risks of opening the site to new species such as *Rhus glabra*, a shrub that has the potential to out-compete shade-intolerant post oak seedlings.

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THE CHEMICAL CHARACTERIZATION OF ORGANIC FUNCTIONAL GROUPS: AN EXPERIMENT FOR THE ADVANCED HIGH SCHOOL CHEMISTRY LABORATORY

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ABSTRACT: The time limitation placed on laboratory activities, the use of flammable solvents and corrosive chemicals, and the need for expensive glassware precludes the use of extensive organic synthesis in the high school laboratory. A scheme is presented in this paper to identify chemically whether a pure organic, mono-functional compound is a carboxylic acid, acid anhydride, alcohol, aldehyde, amide, amine, ester, ether, ketone, phenol, or hydrocarbon. The classification reactions are performed on a semimicro scale using inexpensive reagents. The experiment is written as an "open-ended" project that requires each student to make decisions that are based upon individual observations.

KEYWORDS: Organic chemistry, laboratory experiments, functional groups, chemical characterization.

INTRODUCTION

An introduction to organic functional group chemistry is now a part of many college-level, introductory chemistry courses, especially the course for the non-science major and, to a lesser extent, the chemistry course for the science major. Therefore, units emphasizing organic chemistry have a place within the advanced high school chemistry course.

Many of the organic syntheses that are done at the college level require the use of corrosive reagents, appreciable amounts of starting materials, flammable and toxic solvents, and expensive glassware. Furthermore, their completion requires longer than 50 minutes. Such constraints limit the number of organic synthesis experiments, in which products are isolated, purified, and characterized, that are amenable for use in high school.

The student's laboratory experience should introduce organic reactions and serve as a pedagogical adjunct to the lecture in the organic chemistry unit of study. Laboratory exercises that establish chemically the presence of a particular functional group in an organic compound meet these criteria. The experimental test procedures should require simple equipment, use minimum amounts of inexpensive and non-corrosive chemicals, be capable of rapid completion, and allow the differentiation between various functional groups. A set of test procedures that are performed on a semimicro scale satisfy these constraints.

Two examples of organic functional group analysis experiments are worth citing. They are easily adaptable for use in the high school laboratory. Silvert (1987) describes an exercise in which organic compounds can be identified as alcohols, aldehydes, or ketones. The test reagents are acidified sodium dichromate solution, iodine dissolved in potassium iodide solution, 10% sodium

Table 1. Equipment and reagents required at a student workstation.

Equipment	Reagents
6 - 3" test tubes with corks	6 M hydrochloric acid (HCl)
3 - 4" test tubes with corks	6 M sodium hydroxide (NaOH)
1 - 10 mL graduate	15 M ammonium hydroxide (NH ₄ OH)
2 - 5" glass stirring rods	5% ferric chloride (FeCl ₃)
2 - medicine droppers with bulbs	2% potassium permanganate (KMnO ₄)
1 - 50 mL beaker	ceric nitrate reagent (dissolve 40 g
1 - 100 mL beaker	(NH ₄) ₂ Ce(NO ₃) ₆ in 100 mL of 2 M HNO ₃)
1 - micro metal spatula	chromic acid reagent (dissolve 25 g CrO ₃ in
1 - 125 mL plastic wash bottle	25 mL of conc. H ₂ SO ₄ ; cautiously add to 75
1 - centrifuge test tube brush	mL of distilled water with vigorous stirring)
1 - wooden clothespin-type test	2,4-dinitrophenylhydrazine reagent (dissolve
tube holder	3 g 2,4-dinitrophenylhydrazine in 15 mL of
1 - test tube block	conc. H ₂ SO ₄ ; cautiously pour with stirring
	into a mixture of 70 mL of 95% ethanol and
	20 mL of distilled water)
	95% ethanol (the denatured alcohol from the
	drugstore is suitable as a solvent)
	acetone (the acetone from the drugstore is
	suitable as a solvent)
	tetrahydrofuran

hydroxide solution, and 2,4-dinitrophenylhydrazine (DNPH) solution. Griswold and Rauner (1991) outline a procedure to differentiate between primary, secondary, and tertiary alcohols, aldehydes, ketones, phenols, alkenes, and ethers. Their scheme employs nine separate tests: a water solubility test, an ignition test, the Baeyer test, the iodoform test, the Lucas test, the ferric chloride test, the ceric nitrate test, the reaction with DNPH solution, and the reaction with a solution of bromine dissolved in carbon tetrachloride.

The experiment presented here is an open-ended exercise that deals with the identification of the following functional groups: alcohols (primary, secondary, or tertiary), aldehydes, amides, amines (primary aliphatic or aromatic, secondary aliphatic or aromatic, or tertiary), carboxylic acids, acid anhydrides, esters, ethers, hydrocarbons (saturated, unsaturated, or aromatic), ketones, and phenols. The inclusion of a larger number of functional groups introduces more organic reactions and affords a broader view of the subject. Salts of amines and carboxylic acids are excluded as possibilities in the identification procedures.

The chemical principles of the tests are outlined within the experiment; consequently, the laboratory experience can provide the basis for further discussion during formal class time. The student soon appreciates that qualitative organic functional group analysis is not as formalized as is qualitative inorganic ionic analysis. The tests in organic functional group analysis are not as sensitive as those in inorganic ionic analysis, and in many instances, no single test is specific for a particular functional group. Several functional groups may react differently with the same reagent. Impurities in the sample can lead to an incorrect interpretation of experimental observations.

Table 2. Special reagents and test compounds for the side shelf.

Special Reagents	Test Compounds
Solids	
ferric ammonium sulfate ($\text{Fe}(\text{NH}_4)(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$)	primary alcohol (1-butanol)
potassium thiocyanate (KCNS)	secondary alcohol (2-butanol)
anhydrous aluminum chloride (AlCl_3)	tertiary alcohol (2-methyl-2-propanol)
2-naphthol ($\text{C}_{10}\text{H}_7\text{OH}$)	aldehyde (butanal)
citric acid ($\text{C}_6\text{H}_8\text{O}_7$)	amide (acetamide)
	primary aliphatic amine (benzylamine)
	primary aromatic amine (2,5-dichloroaniline)
Liquids	
acetic anhydride ($\text{C}_4\text{H}_6\text{O}_3$)	secondary amine (dibutylamine)
chloroform (CHCl_3)	tertiary amine (tributylamine)
	anhydride (propionic anhydride)
	carboxylic acid (benzoic acid)
	ester (propyl acetate)
Solutions	
1% sodium nitroprusside ($\text{Na}_2\text{Fe}(\text{CN})_5(\text{NO}) \cdot 2\text{H}_2\text{O}$)	ether (tetrahydrofuran)
1% sodium nitrite (NaNO_2)	saturated hydrocarbon (cyclohexane)
4% potassium iodate (KIO_3)	unsaturated hydrocarbon (cyclohexene)
0.1% soluble starch	aromatic hydrocarbon (benzene)
2% potassium iodide (KI)	ketone (2-butanone)
0.5% nickel chloride ($\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$)	phenol (phenol)
saturated with carbon disulfide (CS_2)	
1M hydroxylamine hydrochloride ($\text{NH}_2\text{OH} \cdot \text{HCl}$) in 95% ethanol	
Lucas reagent (dissolve 160 g anhydrous ZnCl_2 in 100 mL of conc. HCl)	

THE CLASSIFICATION TESTS

An analytical scheme cannot easily be written for qualitative organic functional group analysis. The student performs ten Exploration Activities on a set of known organic compounds prior to identifying an unknown compound. The procedures are carried out on a semimicro scale, using 10-50 mg samples of compound dissolved in a suitable solvent. Each classification reaction normally requires no more than a total volume of 1-2 mL of solution. The procedures have been adapted from journal articles and qualitative organic analysis texts. The test procedures were verified using organic chemicals that were found in the chemical storeroom at DePauw University. A listing of the compounds that were used to verify the test procedures appears as part of each Exploration Activity.

Table 1 lists the equipment and the set of reagents available at each student workstation. The reagents are conveniently stored in 30 mL dropping bottles equipped with dropping pipets. The bottles can be collectively organized in a plastic tray and shared with neighboring students in the class. Table 2 lists those special reagents that are necessary for some of the procedures and lists a set of

mono-functional organic compounds, which can be used to illustrate the interaction of the various reagents with specific functional groups. The representative compounds are stored in appropriate containers on a laboratory side shelf. Students may not remove these substances from the side shelf; they carry samples to their workstation as needed.

As a prelude to the discussion of the various Exploration Activities, each procedure is only outlined. A copy of the actual experiment can be obtained from the author. Certain traditional classification tests such as the solubility of the organic compound in concentrated sulfuric acid solution, the reaction of alcohols with acetyl chloride to form esters, the reaction of carboxylic acids with thionyl chloride to form acid chlorides which can be esterified, and the use of a solution of bromine in carbon tetrachloride to indicate unsaturation in the organic molecule, are purposely omitted in order to avoid using potentially dangerous chemicals. Labeled waste containers must be placed at the workstations into which students discard their reaction mixtures rather than dumping them into the sink.

The hazardous nature of certain chemicals that are used in the classification procedures requires cautious experimentation by the student. Safety glasses must be worn. Organic chemicals are combustible, and many are volatile; consequently, heating operations should be carried out on hot plates or in hot water baths. Inhaling solid dust or liquid vapor during manipulative procedures must be avoided. Students should be warned that when any chemical inadvertently comes in contact with the skin, they should immediately flush the area with copious amounts of water. They should notify the teacher when chemicals are spilled on the work surface to receive instructions as to how to clean the area. Even though the procedures are performed on a semimicro scale, accidents can occur. Those chemicals that are especially hazardous will be identified as part of the Exploration Activity.

Exploration 1. The Solubility in Water, HCl Solution, and NaOH Solution: The Acid-Base Characteristics of the Functional Groups. The solubility of 20-30 mg of solid compound or 1 drop of liquid compound is determined in 2 mL of distilled water, in 2 mL of 1.2 M hydrochloric acid solution, and in 2 mL of 1.2 M sodium hydroxide solution. For water soluble compounds, the acid-base character of the solution is determined using universal indicator solution. For water-insoluble compounds, their solubility in 1.2 M hydrochloric acid solution and, if insoluble in the acid, in 1.2 M sodium hydroxide solution determines their acid-base character. Test the set of known organic compounds and categorize the functional group types as:

Basic: Amines;

Neutral: Alcohols, aldehydes, amides, esters, ethers, hydrocarbons, and ketones;

Acidic: Acid anhydrides, carboxylic acids, and phenols.

Acid anhydrides are neutral compounds; however, they rapidly hydrolyze to carboxylic acids in water. The instructor should be certain that each student categorizes the functional group types correctly.

Exploration 2. The Ferrox Test, a Qualitative Test to Indicate the Presence of Oxygen in Organic Molecules. The ferrox test as described by Davidson (1940) depends upon the solubility of ferric thiocyanate (ferric

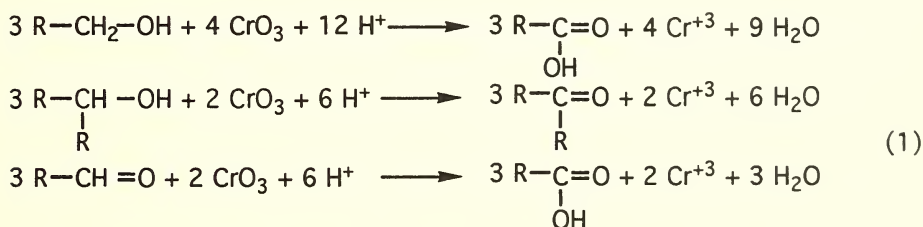
hexacyanoferrate) in liquid organic compounds that contain oxygen. Some amines give a positive ferrox test. However, the test is most effective when used to distinguish hydrocarbons from the remaining types within the neutral category.

Crush and mix solid ferric ammonium sulfate dodecahydrate and solid potassium thiocyanate together until a dark solid is formed. Transfer a few crystals of the solid to a dry test tube. Cover the crystals with 3-4 drops of the liquid organic compound. Oxygen containing organic liquids will dissolve some of the solid; a red solution is produced.

A strong, positive ferrox test was observed with all of the alcohols, aldehydes, ketones, esters, dialkyl ethers, and amides that were tested: allyl alcohol, methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-2-propanol, 2-methyl-1-propanol, 2-pentanol, 3-ethyl-3-pentanol, cyclohexanol, cyclooctanol, benzyl alcohol, 1,4-butanediol, acetaldehyde, propanal, butanal, pentanal, benzaldehyde, p-tolualdehyde, acetone, acetophenone, cyclohexanone, 4-methyl-2-pentanone, 3-pentanone, 2,4-pentanedione, methyl acetate, ethyl acetate, phenyl acetate, methyl benzoate, butyl butanoate, benzyl butanoate, diethyl phthalate, ethyl 4-methoxybenzoate, p-tolyl acetate, diethyl ether, 1,2-dimethoxyethane, 1,4-dioxane, tetrahydrofuran, dibutyl ether, isoamyl ether, N,N-dimethylformamide, N,N-dimethylacetamide, and N-methylacetamide. The alkyl-aryl ethers, phenetole, anisole, and p-methylanisole, gave a faint ferrox test, but the diaryl ether, diphenyl ether, gave a negative test. All of the hydrocarbons that were tested gave a negative ferrox test: benzene, toluene, hexane, octane, mesitylene, cyclohexane, cyclohexene, pentane, p-xylene, and pinene.

Exploration 3. The Chromic Acid Oxidation of Alcohols and Aldehydes.

Bordwell and Wellman (1962) discuss the use of chromic acid reagent to distinguish between tertiary and primary or secondary alcohols; Morrison (1965) extends its use to distinguish between aldehydes and ketones. Chromic acid reagent reacts rapidly with acetone solutions of primary alcohols, secondary alcohols, and aldehydes with the formation of a green to blue-green precipitate (Equation 1).



Warning! Chromic acid is a strong oxidizing agent and is a known human carcinogen. Caution your students to handle the chromic acid reagent with care. Clean up any spills immediately, and if any reagent is spilled on the skin, wash the area immediately with water.

Primary and secondary alcohols react within 15 seconds without heating; aldehydes react less rapidly and may require heating in a water bath at 50° C. Those alcohols and aldehydes that react positively with the chromic acid reagent are methanol, ethanol, 1-propanol, 2-propanol, 2-methyl-1-propanol, 1-butanol, 2-butanol, 1-pentanol, 2-pentanol, 2-phenylethanol, benzyl alcohol, 4-methoxybenzyl

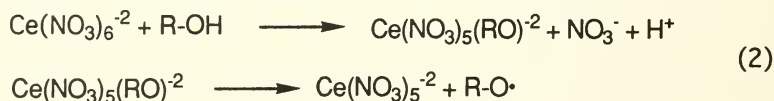
alcohol, 1,10-decanediol, 2-methoxyethanol, cholesterol, cyclohexanol, cyclooctanol, acetaldehyde, propanal, butanal, 2-methylpropanal, pentanal, heptanal, benzaldehyde, o-chlorobenzaldehyde, o-methoxybenzaldehyde, p-nitrobenzaldehyde, naphthaldehyde, piperonal, cinnamaldehyde, and 4'-formylacetanilide.

Phenols give a dark precipitate with chromic acid reagent. Amines form an orange salt that is insoluble in acetone. 2-Aminoethanol and 2-(N,N-dimethylamino) ethanol form an orange salt rather than the oxidation product. Tertiary alcohols, amides, carboxylic acids, acid anhydrides, esters, ethers, ketones, and hydrocarbons do not react.

Exploration 4. The Ceric Nitrate Reagent Test for Alcohols and Phenols.

Duke and Smith (1940) describe the use of the hexanitrate cerate ion to detect the presence of alcohols and phenols. Ceric nitrate reagent reacts with water-soluble alcohols in aqueous medium producing an orange to orange-red complex. A similar reaction occurs for water-insoluble alcohols dissolved in tetrahydrofuran (THF). Those alcohols that gave a positive ceric nitrate reagent test are methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-2-propanol, 2-methyl-1-propanol, 3-ethyl-3-pentanol, cyclohexanol, benzyl alcohol, 2-phenylethanol, cholesterol, 2-methoxyethanol, cyclooctanol, 1,10-decanediol, glycerol, 2-phenoxyethanol, isoamyl alcohol, and allyl alcohol.

The color is transient with alcohols because cerium(IV) is an oxidizing agent. The color is due to the formation of a pentanitratealkoxy cerium(IV) anion complex. An electron is then transferred to the cerium(IV) species from the alkoxy ion producing the colorless pentanitrate cerium(III) anion and an alkoxy radical, which is eventually oxidized to an aldehyde or a ketone (Equation 2).

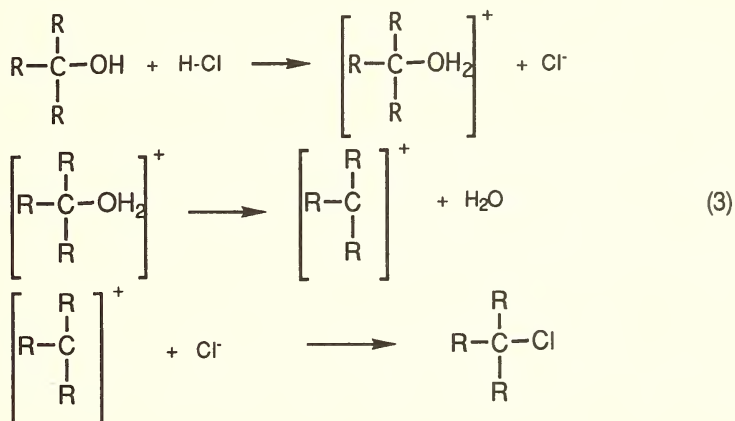


Substituting a phenol or an aromatic amine for the alcohol in the THF procedure produces an intense red, soluble complex. This test is especially useful as a supplementary test for phenols. Some phenols (e.g., 2-naphthol) do not give a positive ferric chloride test (Exploration 9). Those phenols that gave a positive test are phenol, salicylaldehyde, methyl, salicylate, o-hydroxybiphenyl, N-acetyl-p-aminophenol, p-hydroxybenzaldehyde, p-methoxyphenol, p-benzylphenol, p-nitrophenol, p-hydroxybenzoic acid, p-chlorophenol, and propyl p-hydroxybenzoate.

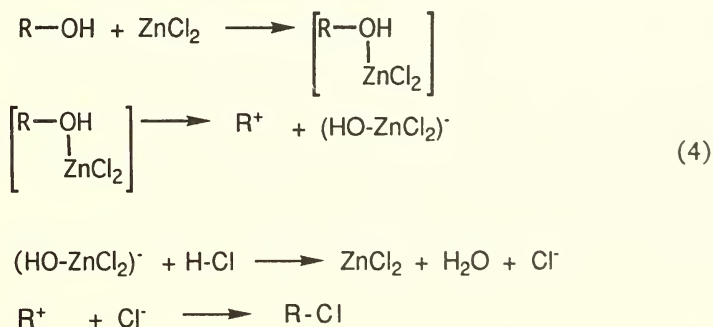
Exploration 5. The Lucas Test for Primary, Secondary, and Tertiary Alcohols. The test procedure is from the text by Cheronis and Entrikin (1963). This test is limited to water-soluble alcohols and depends on the relative times required for cloudiness to develop throughout the solution, when the alcohol is mixed with a solution of zinc chloride dissolved in concentrated hydrochloric acid solution. This cloudiness is due to the formation of an insoluble alkyl chloride. As a rule of thumb, tertiary alcohols react within 1 minute, secondary alcohols within 5 minutes, and primary alcohols in 10 minutes or more. Exceptions are the primary alcohols, allyl alcohol, benzyl alcohol, and cinnamyl alcohol, which react as though they are tertiary alcohols.

Warning! Concentrated hydrochloric acid solution is a hazardous substance. Avoid inhaling its vapors, and if it comes in contact with the skin, immediately flush the area with water. Then swab the area with a solution of sodium bicarbonate to neutralize any acid that is left. Finally, wash the affected area again.

The chemistry of this reaction offers the opportunity to discuss a reaction mechanism. Tertiary alcohols react with concentrated hydrochloric acid solution in the absence of zinc chloride; primary and secondary alcohols do not. The reaction pathway for tertiary alcohols involves the attack on the alcohol by a proton to form a reactive intermediate, the decomposition of the reactive intermediate to a trialkyl carbocation and water, and the reaction of the carbocation with the chloride ion to form an alkyl chloride (Equation 3).

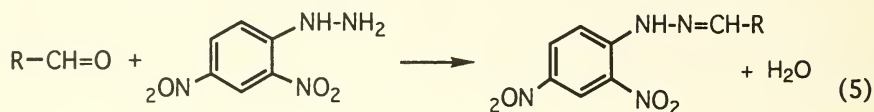


Zinc chloride acts as a Lewis acid with primary and secondary alcohols, initially coordinating with an unshared electron pair on oxygen to form an unstable intermediate. The intermediate loses the dichlorohydroxyzincate anion to form a carbocation. The carbocation then reacts with a chloride ion to generate an alkyl chloride (Equation 4).



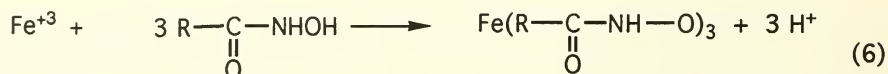
Exploration 6. 2,4-Dinitrophenylhydrazine (DNPH), a Reagent Specific for Aldehydes and Ketones. The test procedure is from the text by Shriner, Fuson, Curtin, and Morrill (1980). DNPH reacts with the carbonyl group of most

aldehydes and ketones in an ethanol-water medium to form an orange to orange-red precipitate, a 2,4-dinitrophenylhydrazone. The reaction is shown with a representative aldehyde (Equation 5).

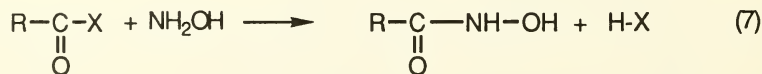


The reaction of aldehydes and ketones occurs almost immediately at room temperature; it was necessary to warm one aldehyde, butanal, and the DNPH reagent at 50° C for 5 minutes to promote their reaction. Esters, amides, acid anhydrides, and carboxylic acids, all of which contain a carbonyl group, do not react with DNPH reagent. Easily oxidized alcohols, such as allyl alcohol, give a positive test as they are first transformed into the aldehyde; however, this reaction is quite slow and only a small amount of product forms. The aldehydes and ketones that gave a positive test with the DNPH reagent are acetaldehyde, pentanal, 2-ethylhexaldehyde, benzaldehyde, 2-chlorobenzaldehyde, butanal, 1-naphthaldehyde, piperonal, p-tolualdehyde, salicylaldehyde, acetone, 3-methyl-2-butanone, 2-pentanone, 3-pentanone, cyclohexanone, 2,4-pentanedione, acetophenone, cyclopentanone, and benzophenone.

Exploration 7. The Hydroxamic Acid Test for Amides, Acid Anhydrides, and Esters. Hydroxamic acids may be thought of as N-hydroxy derivatives of amides or as oximes of carboxylic acids. Hydroxamic acids combine with the ferric cation in acid media to form an intensely colored, neutral complex (Equation 6). Hydroxamic acids are synthesized by the reaction of



hydroxylamine with carboxylic acid derivatives such as acid chlorides, acid amides, esters, and acid anhydrides (Equation 7). A comprehensive review of the



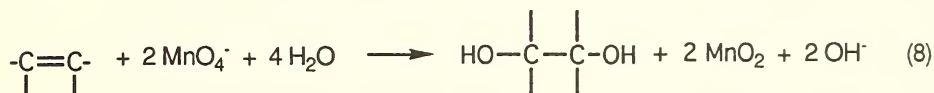
utility of organic functional group identification via hydroxamic acid formation and complexation with ferric chloride solution is given by Davidson (1940).

Buckles and Thelan (1950) point out that amides and acid anhydrides form hydroxamic acids when heated in boiling water with 1 M hydroxylamine hydrochloride solution in 95% ethanol in either acidic or basic solution. Esters react only in a basic environment. The procedure of Buckles and Thelan is the basis for the classification test. Suspected amides or acid anhydrides are treated with the hydroxylamine hydrochloride reagent in an acid medium; suspected esters are treated with this reagent in a basic medium. The color of the ferric

hydroxamate complex is most intense and requires the shortest induction period for its formation at a pH between 1 and 2. The excess acid or base is neutralized prior to adding the ferric chloride solution. The development of a red color throughout the solution is a positive test.

The acid anhydrides, amides, and esters which gave a positive ferric hydroxamate test are acetic anhydride, propionic anhydride, butyric anhydride, succinic anhydride, benzoic anhydride, phthalic anhydride, acetamide, N-methylacetamide, propionamide, N,N-dimethylacetamide, N,N-dimethylformamide, benzamide*, acetanilide*, p-acetotoluidide*, methyl acetate, ethyl acetate, methyl propionate, methyl butyrate, methyl phenylacetate, propyl benzoate, isobutyl benzoate, and phenyl benzoate. Those amides that are designated by an asterisk gave a slight, but discernable, positive ferric hydroxamate test. N-Phenylbenzamide did not give a positive hydroxamate test under the reaction conditions in acid media. Because many phenols react with ferric chloride solution to produce a colored complex (Exploration 9), the test is invalid, if a phenolic, hydroxy group is present in the molecule.

Exploration 8. Tests for Hydrocarbons, Neutral Compounds That Give a Negative Ferrox Test. *Unsaturation* in hydrocarbons is detectable using the Baeyer Test as described by Cheronis and Entrikin (1963). Unsaturated hydrocarbons react rapidly with neutral potassium permanganate solution, producing a brown precipitate of manganese dioxide (Equation 8); saturated and



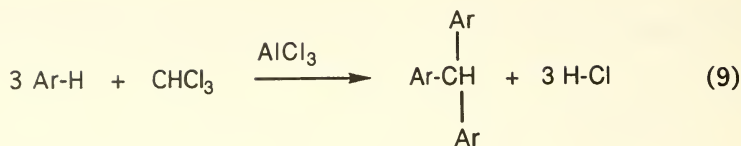
aromatic hydrocarbons do not react with this reagent. The initial reaction involves the formation of a glycol. The unsaturated hydrocarbons that gave a positive Baeyer test are 1-pentene, cyclohexene, 1,7-octadiene, 1,3-cyclooctadiene, 1,5,9-cyclododecatriene, 1-hexene, and 1,2-diphenylethylene.

Phenols, aromatic amines, and aldehydes give a positive test; however, phenols and amines are in a different solubility classification than hydrocarbons, and aldehydes react with DPNH reagent whereas hydrocarbons do not. Swinehart (1964) observes that some alcohols do appear to give a positive Baeyer test. He traces the cause to the presence of oxidizable impurities in the alcohol sample.

Aromatic hydrocarbons respond using the procedure suggested by Cheronis (1958). The test involves the reaction of the hydrocarbon with chloroform in the presence of anhydrous aluminum chloride. A positive test is indicated by the development of an intense color, which can range from yellow through green to purple, on the surface of the aluminum chloride.

Warning! Polynuclear, aromatic hydrocarbons are known human carcinogens. Avoid inhaling any solid dust or liquid vapor. The reaction of anhydrous aluminum chloride with moisture is highly exothermic; hydrogen chloride gas is evolved. Handle this chemical cautiously.

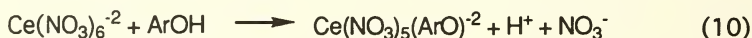
This reaction is a Friedel-Crafts condensation of chloroform with the aromatic nucleus in the presence of an aluminum chloride catalyst (Equation 9). The overall reaction is a stepwise process. The color formation is attributed to



the production of a small amount of the triarylmethyl tetrachloroaluminate ion pair during the reaction. Those aromatic hydrocarbons that gave a positive test are benzene, toluene, naphthalene, phenanthrene, stilbene, and biphenyl.

The test is positive for any neutral compound that contains an aromatic nucleus. The differentiation of hydrocarbons from other neutral molecules depends upon the ferrox test. Those aryl and diaryl ethers which give a negative or faint ferrox test will give a positive test for the aromatic nucleus; hence, they might be identified as aromatic hydrocarbons. Saturated aliphatic hydrocarbons give negative tests for unsaturation as well as for the presence of the aromatic nucleus.

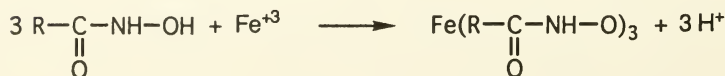
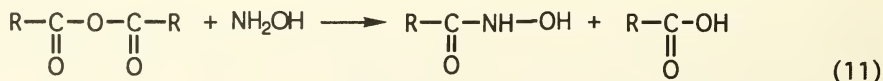
Exploration 9. Test for Compounds in the Acidic Group: Phenols, Acid Anhydrides, and Carboxylic Acids. *Phenols* can be identified using ceric nitrate reagent (Equation 10) and THF as described in Exploration 4. The presence of a phenolic



hydroxyl group is indicated by the appearance of an intense red color throughout the solution. Those phenols that are listed in Exploration 4 gave a positive test.

Many phenols in ethanolic solution become intensely colored when a drop of 5% ferric chloride solution is introduced. The color may range from brown to orange, through green to blue or violet. Wesp and Brode (1934) report that 11 of 60 phenols did not give a positive ferric chloride test. In a later study, Soloway and Wilen (1952) observed that 38 of 86 phenols gave a negative ferric chloride test. They suggest that the procedure employ chloroform as the solvent for the phenol and the ferric chloride and that a drop of pyridine be added to the system. Only 11 of the 86 phenols gave a negative test with this modified procedure. The only phenol that is listed in Exploration 4 that does not give a positive ferric chloride test is 2-naphthol.

Acid anhydrides react with hydroxylamine when heated in acid medium to form a hydroxamic acid, which reacts with ferric chloride solution to form the colored complex (Equation 11; see Exploration 7). Those acid anhydrides that



are listed in Exploration 7 reacted positively. Carboxylic acids do not interfere, while phenols do, as has been noted previously.

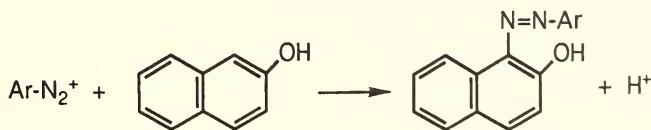
Carboxylic acids are recognizable using the procedure of Feigl and Anger (1966). An ethanolic solution of the acid liberates iodine when mixed with a mixture formed from 2% potassium iodide solution and 4% potassium iodate solution (Equation 12). The iodine is characterized by the formation of a blue



complex with a 0.1% starch solution. The acids that gave a positive test are formic acid, acetic acid, propionic acid, n-butyric acid, i-caproic acid, diphenylacetic acid, benzoic acid, 3,5-dinitrobenzoic acid, o-nitrobenzoic acid, phthalic acid, p-hydroxybenzoic acid, succinic acid, o-chlorobenzoic acid, 2-furoic acid, salicylic acid, and oxalic acid. Because acid anhydrides hydrolyze in aqueous solution, they also give a positive test.

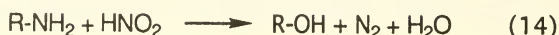
Exploration 10. Test for Compounds in the Basic Group: Primary Alkyl and Aryl Amines, Secondary Amines, and Tertiary Amines. *Primary alkyl amines* are distinguishable using the Rimini test as described in Cheronis and Entrikin (1963). A very dilute solution of the primary aliphatic amine in acetaldehyde-free acetone reacts within 2 minutes with 1% sodium nitroprusside reagent to form a red-violet solution. The test is specific for primary aliphatic amines; primary aromatic amines, secondary aliphatic and aromatic amines, and tertiary amines do not interfere. The amines that gave a positive Rimini test are 2-phenylethylamine, dl 1-phenylethylamine, ethylenediamine, n-butylamine, isobutylamine, n-propylamine, benzylamine, dl alpha-methylbenzylamine, 1,6-hexanediamine, cyclohexylamine, isopropylamine, 3-amino-1-propanol, and diethylenetriamine.

Primary aromatic amines can be uniquely detected by initially forming a solution of the diazonium salt of the amine and then coupling the salt with 2-naphthol (Equation 13). The procedure is found in the text by Owen (1969).

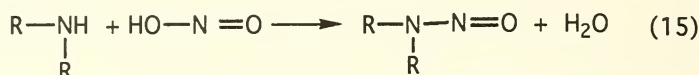


The amine is dissolved in 1.2 M hydrochloric acid solution, cooled in an ice bath, and then 1% sodium nitrite solution is added to the cold amine hydrochloride solution. This cold solution is then added to a solution of 2-naphthol dissolved in 2.4 M sodium hydroxide solution. The formation of an orange to red precipitate of an arylazonaphthol indicates a primary aromatic amine. Those primary aromatic amines that gave an insoluble condensation product with 2-naphthol are aniline, m-toluidine, p-chloroaniline, m-chloroaniline, 2,5-dichloroaniline, m-nitroaniline, 2,5-dimethylaniline, o-aminobiphenyl, 2-ethylaniline, and ethyl p-aminobenzoate.

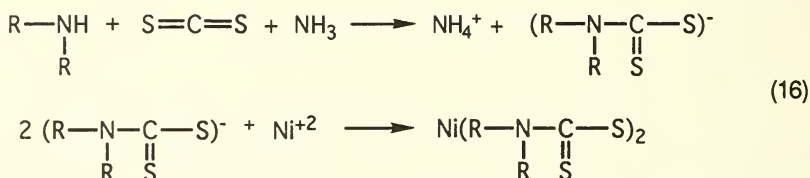
Primary aliphatic amines do react with nitrous acid, liberating nitrogen gas (Equation 14).



Secondary amines also react with nitrous acid to produce an N-nitrosamine which separates from solution as an oil or a solid (Equation 15). Under these reaction conditions, tertiary amines simply protonate forming the tertiary amine cation, R_3NH^+ .



Secondary amines react with an ammoniacal solution of 0.5% nickel chloride that is saturated with carbon disulfide to form an insoluble, nickel (N,N-disubstituted)dithiocarbamate salt (Equation 16). Duke (1945) discusses the procedure and the reaction parameters.



Secondary alkyl amines form a yellow to green colored precipitate, and secondary aromatic amines form a white to tan precipitate. The secondary amines that gave a test with the nickel chloride-carbon disulfide reagent are dicyclohexylamine, diethylamine, dibutylamine, N-(2-ethylhexyl)cyclohexylamine, N-benzyl-o-toluidine, N-butylaniline, N-propylaniline, N-methylaniline, N-methyl-p-toluidine, and N-methyl-o-toluidine. Primary and tertiary amines do not interfere; however, diethylenetriamine, a mixed primary and secondary amine, only gave a positive Rimini test and failed the nickel chloride-carbon disulfide reagent test.

Tertiary amines are identifiable using the procedure in Feigl and Anger (1966). A tertiary amine, when heated at 100° C in a 2% solution of citric acid in acetic anhydride, forms a red to purple colored solution within two minutes. Because the citric acid-acetic anhydride solution decomposes on standing, a fresh solution must be mixed prior to testing for a tertiary amine. Those tertiary amines that gave a positive test with citric acid-acetic anhydride are N,N-diethylaniline, tri-n-butylamine, N,N-diethylaminoethanol, tribenzylamine, 2-aminopyridine, N,N-dimethylbenzylamine, and 5-methyl-2-aminopyridine. Rather than forming a blue complex with the citric acid-acetic anhydride solution, primary and secondary amines form amides under these reaction conditions. An interesting observation was that 2-aminopyridine and 5-methyl-2-aminopyridine gave a positive citric acid-acetic anhydride test, a negative Rimini test, and liberated nitrogen gas in an acidified nitrite solution.

Table 3. A listing of organic functional group-type compounds.

Primary Alcohols	Secondary Alcohols	Tertiary Alcohols
1-butanol	2-butanol	2-methyl-2-propanol
1-hexanol	cyclohexanol	2-methyl-2-butanol
2-methyl-1-propanol	2-propanol	3-methyl-3-pentanol
Aldehydes	Amides	Primary Aliphatic Amines
butanal	acetamide	benzylamine
4-chlorobenzaldehyde	acetanilide	cyclohexylamine
pentanal	N-methylacetamide	butylamine
Primary Aromatic Amines	Secondary Amines	Tertiary Amines
2,5-dichloroaniline	dibutylamine	tributylamine
ethyl 4-aminobenzoate	diphenylamine	tribenzylamine
4-nitroaniline	N-phenylbenzylamine	N,N-dimethylbenzylamine
Anhydrides	Carboxylic Acids	Esters
propionic anhydride	benzoic acid	propyl acetate
acetic anhydride	acetic acid	phenyl benzoate
phthalic anhydride	propionic acid	butyl benzoate
Ethers	Saturated Hydrocarbons	Unsaturated Hydrocarbons
tetrahydrofuran	cyclohexane	cyclohexene
isopropyl ether	pentane	cyclopentene
butyl ether	hexane	1-hexene
Aromatic Hydrocarbons	Ketones	Phenols
benzene	2-butanone	phenol
naphthalene	acetophenone	p-cresol
biphenyl	cyclohexanone	4-nitrophenol

CONCLUSION

The culmination of this exercise is for the student to classify unknown organic compounds according to their functional group type. Performing the ten Exploration Activities on an unknown will allow a student to determine the identity of the functional group that is present. However, such an approach is quite inefficient. The teacher can profitably require each student to formally outline an experimental procedure before the unknown is issued. As an aid for the preparation of the outline, the instructor should pose a set of questions. These can be specifically designed to stimulate student inspection of the Exploration Activities in order to generate an effective chemical approach to solve a particular problem.

An effective, pedagogical tool to encourage cooperative learning is to have each student formally present his/her experimental observations and to justify his/her conclusion to the class. Class members can then critique the procedure, question the conclusion, and suggest alternate tests that might prove more definitive. After presenting the class report and hearing the ensuing critique, each student can use an additional laboratory period for further experimental study of the unknown compound before turning in the final report to the teacher.

A final observation is that your supply of organic chemicals may preclude doing the experiment in its entirety. However, the organization of the test procedures into separate Exploration Activities permits an easy adaptation to include analysis for a smaller number of functional groups. It is essential to have those chemicals that are required to do the Exploration Activities, the organic functional group test compounds, and a set of unknown compounds. Table 3 provides a listing of organic compounds suitable for this experiment. The amounts of substances that are required are approximately 100 g of a solid and 100 mL of a liquid. The list is only suggestive; any compound that is representative of a particular functional group can be used.

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REPEATED LOADING OF THE SALEM LIMESTONE (INDIANA LIMESTONE; MISSISSIPPIAN)

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ABSTRACT: This paper describes a model for predicting the life expectancy of a rock specimen subjected to repeated loading. A case study based on data obtained from samples of the Salem Limestone (Mississippian) is used to test the hypothesis. The results are summarized in such a way that a "one-point fatigue test" can predict service life at a given stress level.

KEYWORDS: Rock mechanics, fatigue testing, strength predictions.

INTRODUCTION

The fact that a rock will break when struck repeatedly is hardly a new concept. Paleolithic man shaped tools using this principle, and many a cornfield in Indiana is littered with flint or chert flakes from arrowhead manufacturing. In 1881, Thomas H. Johnson reported, "It is well known that a stone however large may be broken by striking a sufficient number of blows with a hammer along a line where it is desired to break the stone. In this process, the force of the blows is expended in gradually weakening the cohesion of the particles in a line following the direction of the blow, until finally rupture occurs." This deterioration of rock strength, where repeated load applications finally break the sample, is illustrated in Figure 1. The author proposes that this gradual breakdown of internal rock structure can be used to predict the fatigue behavior of the rock. Similar research was carried out in France by Bernaix (1974).

MATERIALS AND METHODS

A model is described in this paper, based on a re-analysis of old test data (Johansen, 1971), for predicting the number of load cycles a rock sample can withstand in uniaxial compression. The volumetric strain-uniaxial stress curve rather than the typical uniaxial stress-strain curve was used to predict fatigue behavior. Data from a case study on the Salem Limestone were utilized to develop a graph from which to predict the rock's fatigue behavior. The samples were sawed from a single block of limestone donated by a quarry near Bedford. The samples had nominal dimensions of 2 in. x 2 in. x 5.5 in., and the direction of the bedding was along the long axis of the sample.

FAILURE MECHANISM AND ENERGY CONSIDERATIONS

The uniaxial stress-volumetric strain curve gives a good representation of the internal changes that take place in a rock sample as an increasing uniaxial load is

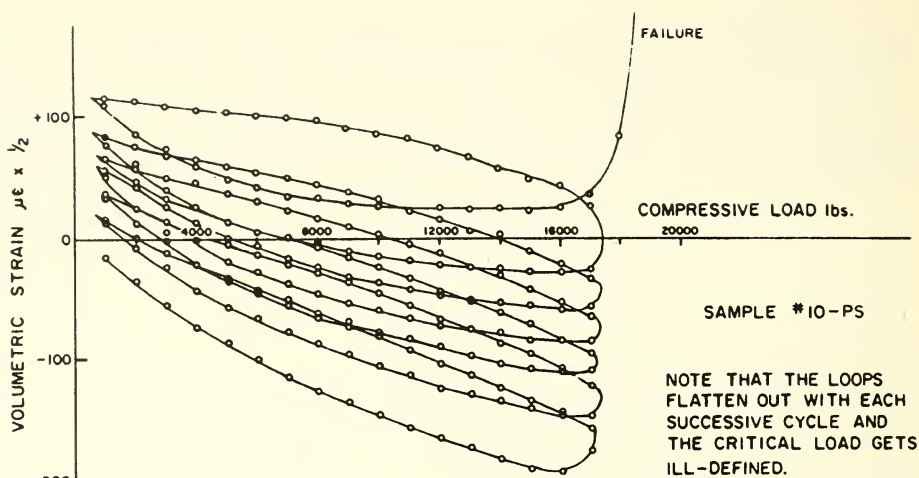


Figure 1. The deterioration of rock strength with repeated load applications.

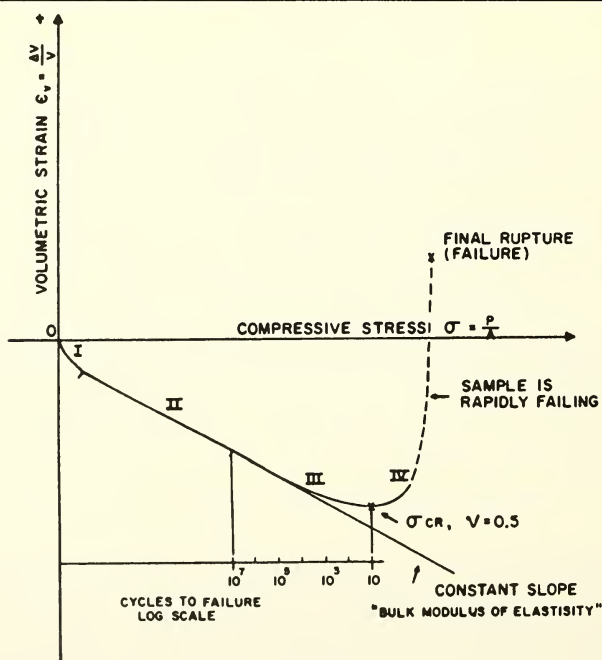


Figure 2. The stress-volumetric strain curve for uniaxial compression.

applied. This process was described by Brace (1963) and was used as part of this study to establish the behavior characteristics of rock (Johansen, 1971).

When a uniaxial load is applied, initially the internal flaws or cracks will close, resulting in a non-linear volume reduction. This process occurs in Region I (Figure 2). Region II depicts the almost linear relationship between uniaxial stress and volumetric strain that follows as the load is increased. Region III shows progressively non-linear behavior due to a change in Poisson's ratio leading to

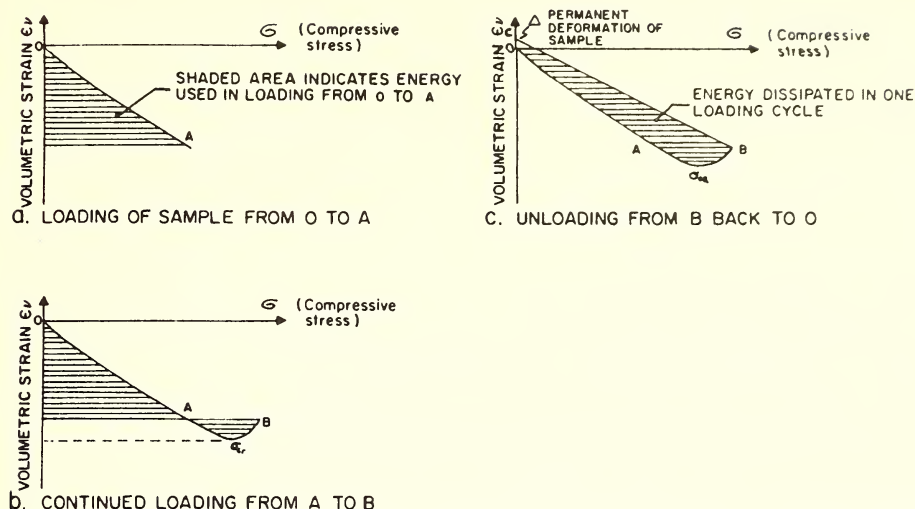


Figure 3. Energy considerations for a stress-volumetric strain curve.

different rates of strain increase in the directions parallel and perpendicular to the axis of applied stress. The volumetric strain curve being the sum of the linear strains will hence be curved as the individual strains increase at different rates. When the differential movement along the shear planes becomes so great that the strength of the rock fabric is exceeded by the stresses in the tips of the cracks formed as the load is applied, the cracks will become self-propagating. If the energy input is greater than what can be dissipated by a single crack, the crack will bifurcate. The process of crack forking is a major contributing factor to the volume change that occurs in Region IV. The fracture process becomes continuous and self-sustaining, and the sample fails. Region IV is known as the region of unstable crack propagation, and here, the internal integrity of the sample is destroyed. Individual parts of the sample can now move independently of each other. The sample undergoes a significant increase in volume, when there is only a minute increase in the applied compressive stress. The volume measured at this point is no longer the volume of the rock sample but the volume of the rock sample plus the volume of the induced fractures. Actually, the rock sample has already failed with the onset of unstable crack propagation. At this load or stress level, it is just a matter of time before physical disintegration of the sample occurs.

Figure 3 also shows that fracturing is a function of the energy input into the sample, since the units along the coordinate axes represent stress (psi) and strain (in/in), respectively. The area within the hysteresis loop has units of in-lb/cubic in or energy per unit volume. The failure process can be thought of as a progressive dissipation of the energy induced by the applied load.

ENERGY DISSIPATION PROCESS

Figure 3c is the stress-volumetric strain curve, representing the energy lost in the specimen (shaded area) as the load is cycled. Upon reloading to the stress level at point B, the curve closely follows the unloading curve until it exceeds the

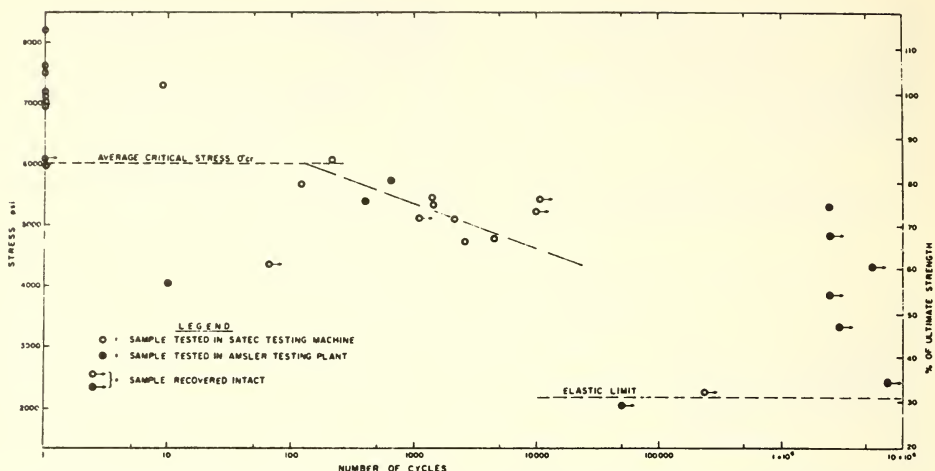


Figure 4. Stress as related to the number of load cycles (S-N curve) for 33 samples of the Salem Limestone.

maximum load imposed in the previous cycle. Figure 1 shows that the energy dissipated during each loading and unloading cycle reduces the area between the volumetric strain curve and the axial stress axis. The total number of cycles needed to fail the specimen may be estimated by dividing the total area between the initial curve and the stress axis by the area within each subsequent hysteresis loop. This value is a measure of the energy loss per cycle (Figure 1).

A problem arises when the area within the hysteresis loop is too small to be readily computed. The solution is provided by the stress-strain curve itself. The curve clearly shows the upper limit of the bulk elastic region as the point where the curve deviates from the straight line portion of Region II. For the Salem Limestone, the point was determined to be 35% of the ultimate uniaxial compressive strength. The samples tested show that repeated loads to this level or less can be applied 10 million times or more (Figure 4).

Another clearly defined point is the critical point (Figure 2). At this stress level, ν or Poisson's ratio is 0.5. No volume change occurs with an increase in compressive stress. The fatigue life at this level, about 85% of the short-term ultimate stress, is of the order of ten to one hundred cycles, depending on the speed of the load applications. The theoretical lower limit, as already discussed, is one cycle or load application.

In order to measure fatigue life in terms of the number of load applications to a given level and avoid the problem of measuring small hysteresis loops, an estimate of the fatigue life can be made directly from the original stress-strain curve. The method is shown in Figure 2. A log scale is introduced over Region III, ranging from 10 million at the start of Region III to ten at the end of the Region. The load level (from the log curve imposed over Region III) gives an estimate of the number of times the rock sample can be loaded to that level.

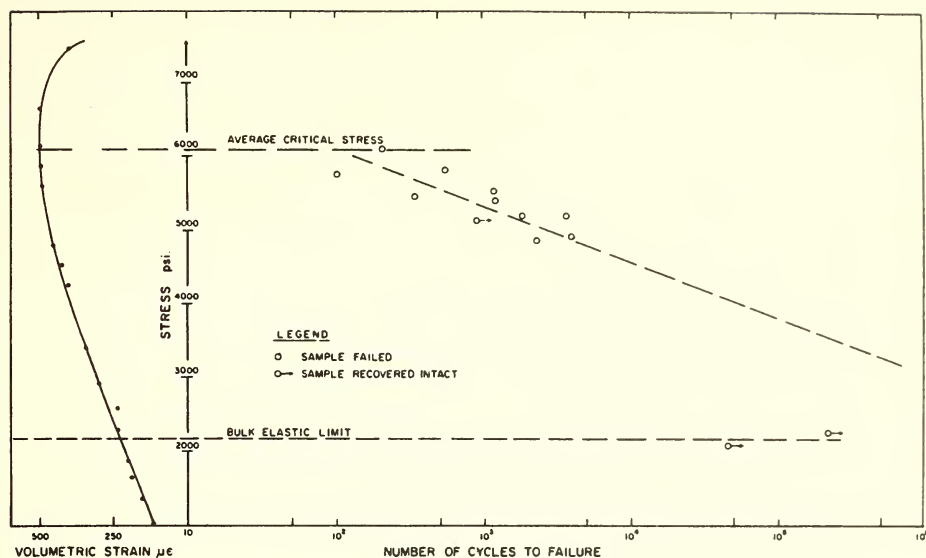


Figure 5. A composite graph showing the relationship between stress level and the corresponding volumetric strain and number of cycles to failure for the Salem Limestone (33 samples).

TEST OF THE MODEL

Figures 4 and 5 summarize the test results for limestone prisms repeatedly tested to various load levels. Figure 4 shows a typical stress to number of cycles curve (S-N curve) for failure of 33 samples from the Salem Limestone. Figure 5 combines these tests with a stress-volumetric strain curve creating a model that can be used for predicting fatigue behavior for this limestone under uniaxial repeated loads. For a given stress level in Region III, the graph gives an estimate of the number of load applications to this level that the sample can be expected to withstand. The curve in Figure 5 can be thought of as a one-point fatigue test. This is again shown in Figure 1.

The curve does, however, have limitations. Adjustments must be made for other types of load applications and, of course, different rock types.

CONCLUSIONS

The proposed model has been shown to predict the long-term fatigue behavior of a limestone subjected to uniaxial repeated loading to a given load level. The model predicts the number of cycles a specimen may withstand at this load level, in effect providing a measure of the long-term life of the rock structure at this stress or load level.

The stress-volumetric strain curve gives a far superior picture of rock behavior than a regular stress-strain curve. The Poisson effect is readily detected in the stress-volumetric strain curve, and the true elastic region can be readily identified.

By directly monitoring the volumetric strain as the sample is loaded, an accurate appraisal of rock strength can be made in any given instance. Rock samples subjected to repeated loading within the bulk elastic region (Region II) will withstand a very large number (greater than 10 million) of load applications. The upper limit of the bulk elastic region is approximately 35% of the conventional, ultimate strength of the Salem Limestone.

Repeated loading past the bulk elastic region as measured from the stress-volumetric strain curve will cause a gradual, progressive failure of the rock specimen. At stress levels greater than the upper limit of the bulk elastic region, a progressive increase in the internal fracturing of the sample occurs. Upon unloading from a stress at this level, the sample shows permanent deformation.

Poisson's ratio changes continuously but exhibits a reasonably constant value in Region II, the bulk elastic region. As the stress level increases, Poisson's ratio increases reflecting the different increases in lateral and axial strain, and the long-term, maximum strength value is the critical stress. At this point, maximum volumetric strain occurs. The point is also characterized by a Poisson's ratio of 0.5 or yield under constant volume. Repeated loading to a stress level greater than the critical stress does not give meaningful results in terms of fatigue life. The sample has essentially failed at this point.

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RADON IN THE SOILS OF MARION COUNTY, INDIANA

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ABSTRACT: Soil radon content was sampled at 484 sites in Marion County, Indiana, to determine the amount of the radon present in the various glacially derived soil types. No correlation was found between radon level and soil type. Soil radon levels were controlled by the mineralogy of the underlying bedrock units, whose contacts were mapped using the radon levels in the soils.

KEYWORDS: Borden Group, Marion County, Muscatatuck Group, New Albany Shale, Radon, Soil, Wabash Formation.

INTRODUCTION

A number of papers have been written on the measurement of radon emanating from soils. The objectives of these studies have been manifold. Some authors have studied the transport mechanisms of radon through the soil fabric (Tanner, 1964; Fleischer and Mongro-Campero, 1978; Tanner, 1980; Luetzelschwab, *et al.*, 1989). Others have studied radon and radium transport in groundwater supplies (Hess, *et al.*, 1979; Michel and Moore, 1980; Horton, 1983). Radon measurements have been used in uranium exploration, and some authors have even suggested that radon measurements might be useful in oil exploration (Card, *et al.*, 1985).

The accumulation of radon in dwellings has been studied in the United States, Sweden, Switzerland, Germany, and other European countries (Steinhaeusler, 1975; Swedish Radon Commission, 1984; Swedjemark, 1984; Scott and Findlay, 1983; Buchli and Burkart, 1989; Reimer and Gundersen, 1989). Hasenmueller (1988) characterized the radon production potential of different areas of Indiana based upon aerial radioactivity, geology, and soil permeability.

A few studies have looked at the radon distribution in soils on a county-wide basis. Gundersen, *et al.* (1988) sampled 567 sites in Montgomery County, Maryland. Schumann and Owen (1988) sampled 123 sites in Fairfax County, Virginia. Otton, *et al.* (1988) published a map of Fairfax County, Virginia, showing the radon potential of the County.

SETTING

Marion County is located in central Indiana (Figure 1) and has a land area of 402 square miles. Approximately 20 percent of the County is still farmland, but this percentage is decreasing as the capital, Indianapolis, expands onto former farms.

Four main soil associations are found in Marion County (Sturm and Gilbert, 1978). The Crosby-Brookston Association, which is found on gently rolling upland till plains, covers approximately 40 percent of the County. The

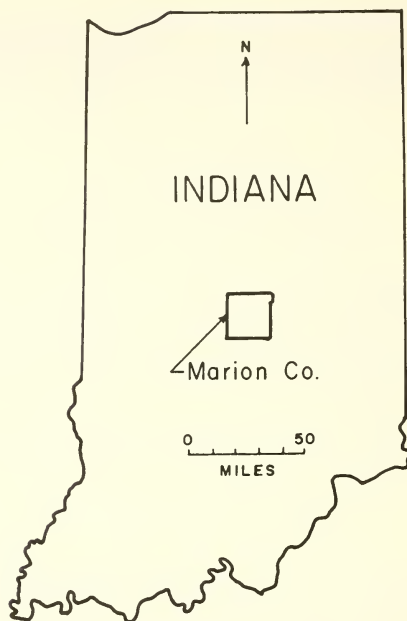


Figure 1. Map of Indiana showing the location of Marion County.

Miami-Crosby Association, which covers approximately 30 percent of the County, is found on dissected upland plains between broad ground moraines and bottom land or between terraces and outwash plains. The Fox-Ockley Association, which covers approximately 18 percent of the County, is found on broad outwash plains and on terraces adjacent to the larger streams. The Genesee-Sloan Association occurs on floodplains along the White River and some of the larger streams, mantling approximately 12 percent of Marion County.

Thirteen soil types were sampled within these four soil associations. The Brookston Series is composed of silty clay loam soils of moderate permeability, which developed on till plains. The Crosby Series consists of silt loam soils with poor permeability, which developed on till plains. The Crosby-Miami soil is a silt loam of moderate permeability, which developed on upland till plains and low knolls. The Eel, Genesee, Shoals, and Sloan Series soils are all silt loams with moderate permeability, which are found on floodplains. The Fox Series soils are loams with moderate to rapid permeability, which occur on outwash plains and terraces. The Hennepin Series soils are loams with moderate permeability,

Table 1. Generalized geologic column of the rock units underlying Marion County (Gray, *et al.*, 1987).

System	Rock unit
Mississippian	Borden Group
Late Devonian	New Albany Shale
Middle Devonian	Muscatatuck Group
Silurian	Wabash Formation

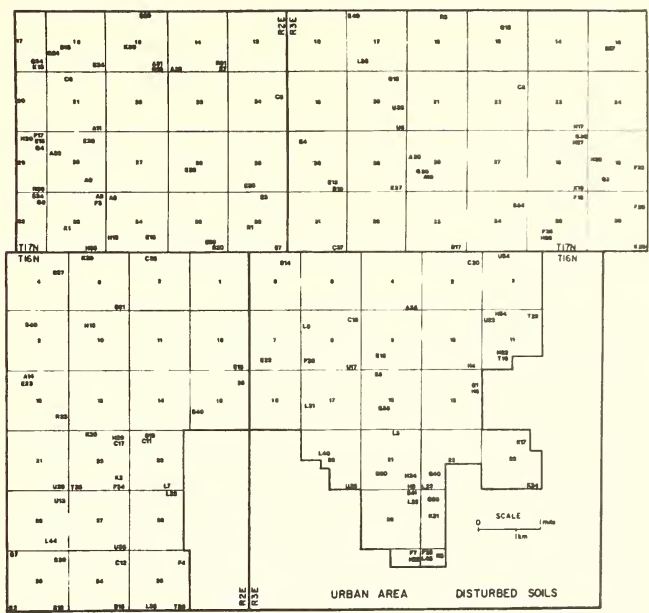


Figure 2. Northwest quarter of Marion County showing soil sample sites; B = Brookston; C = Crosby; R = Crosby-Miami; E = Eel; F = Fox; G = Genesee; H = Hennepin; A = Martinsville; U = Miami; K = Ockley; S = Shoals; L = Sloan; T = Westland.

which developed on steep escarpments. The Martinsville and Ockley Series soils are both silt loams with moderate permeability found on outwash plains and terraces. The Miami Series soils are silt loams with moderate to slow permeability, which occur on till plains. The Westland Series soils are clay loams, which are found on outwash plains and terraces.

Table 2. Soil radon levels in picoCuries/liter (pCi/l) from 421 sample sites in 13 soil types in Marion County, Indiana.

Soil Type	Number Sample Sites	Minimum pCi/l	Maximum pCi/l	Mean pCi/l	Standard Deviation
Crosby	35	0	4650	817	919
Miami	32	50	3600	1055	892
Brookston	37	0	3800	678	706
Genesee	30	0	3050	787	698
Fox	34	50	3150	653	654
Crosby-Miami	32	0	3800	742	749
Sloan	32	100	2500	675	614
Ockley	31	100	3800	942	845
Hennepin	34	0	3400	803	684
Shoals	31	50	2600	690	573
Eel	32	0	2000	494	446
Martinsville	31	50	2750	779	714
Westland	30	50	3800	965	843

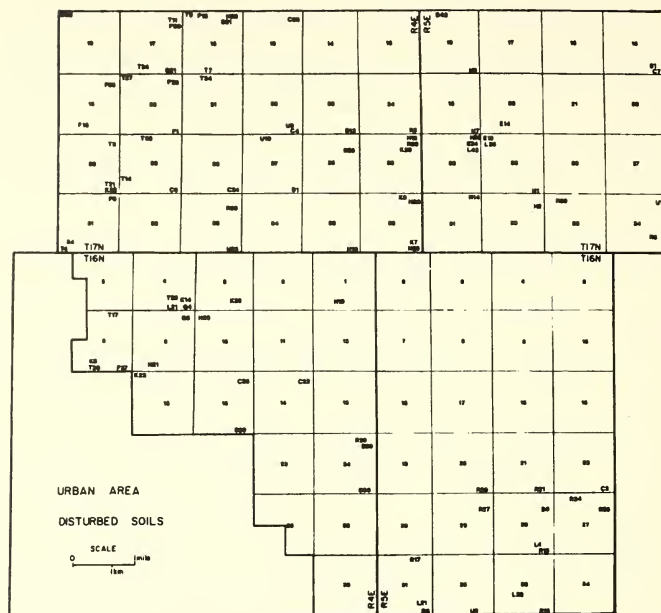


Figure 3. Northeast quarter of Marion County showing soil sample sites; B = Brookston; C = Crosby; R = Crosby-Miami; E = Eel; F = Fox; G = Genesee; H = Hennepin; A = Martinsville; U = Miami; K = Ockley; S = Shoals; L = Sloan; T = Westland.

Large areas of Marion County have been developed for commercial and residential uses. In these areas, the soil structure has been so altered and obscured by construction that identification of the soils is not possible. The areas classified as urban land in the soil survey report of Strum and Gilbert (1978) were not sampled in this study. These areas are in the central part of the County, which has been urbanized for well over one hundred years.

BEDROCK GEOLOGY

The bedrock in Marion County is comprised of sedimentary rock layers dipping gently to the southwest into the Illinois Basin (Harrison, 1963). The oldest bedrock unit is the Silurian Wabash Formation, which is located in the northeastern part of the County and is composed of calcareous shales, argillaceous

Table 3. Soil radon levels from 272 sample sites over four bedrock units as depicted by Gray, *et al.* (1987)

Rock unit	Number Sample Sites	Minimum pCi/l	Maximum pCi/l	Mean pCi/l	Standard Deviation
Borden	36	0	450	249	126
Muscatatuck	64	0	700	230	172
New Albany	129	150	3800	1062	670
Wabash	43	0	4650	1155	1048

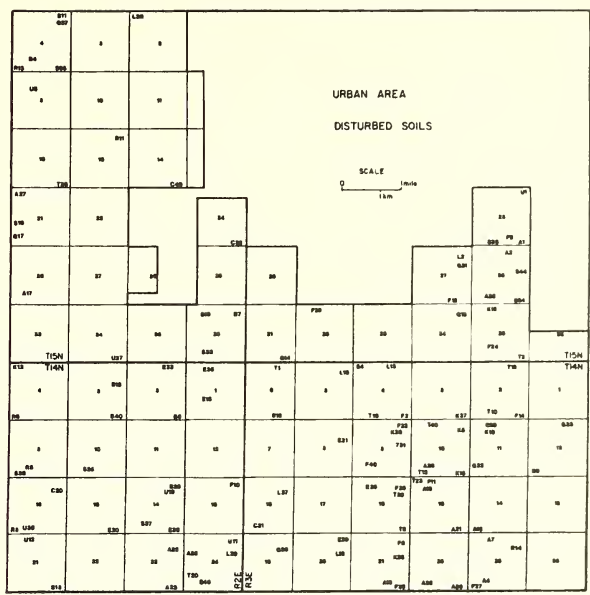


Figure 4. Southwest quarter of Marion County showing soil sample sites; B = Brookston; C = Crosby; R = Crosby-Miami; E = Eel; F = Fox; G = Genesee; H = Hennepin; A = Martinsville; U = Miami; K = Ockley; S = Shoals; L = Sloan; T = Westland.

limestones, and cherty dolomitic limestones. Some reef structures are found within the Wabash Formation, since it was deposited during a time of active reef formation in the Late Silurian. Disconformably overlying the Silurian rocks are the interbedded carbonate rocks of the Devonian Muscatatuck Group. These carbonate rocks are found throughout eastern Marion County. The Middle Devonian to Early Mississippian New Albany Shale overlies the Muscatatuck Group. The New Albany Shale is a carbonaceous black shale which contains small, but measurable, quantities of radioactive elements (Al-Jassar, 1981). The New Albany Shale underlies the northwestern and west-central portions of the County. In southwestern Marion County, the Mississippian Borden Group is found, which consists of thin-bedded limestones, sandstones, siltstones, and shales. The entire County is covered with a mantle of Pleistocene glacial deposits, consisting mainly of tills in the uplands and sands and gravels on the outwash terraces and in the river valleys.

Table 4. Soil radon levels from 484 sample sites over four bedrock units reconfigured based on the bedrock map of Marion County, Indiana (Gray, *et al.* 1987)

Rock unit	Number Sample Sites	Minimum pCi/l	Maximum pCi/l	Mean pCi/l	Standard Deviation
Borden	61	0	450	203	134
Muscatatuck	116	0	700	212	132
New Albany	239	150	3800	1037	642
Wabash	68	0	4650	1193	925

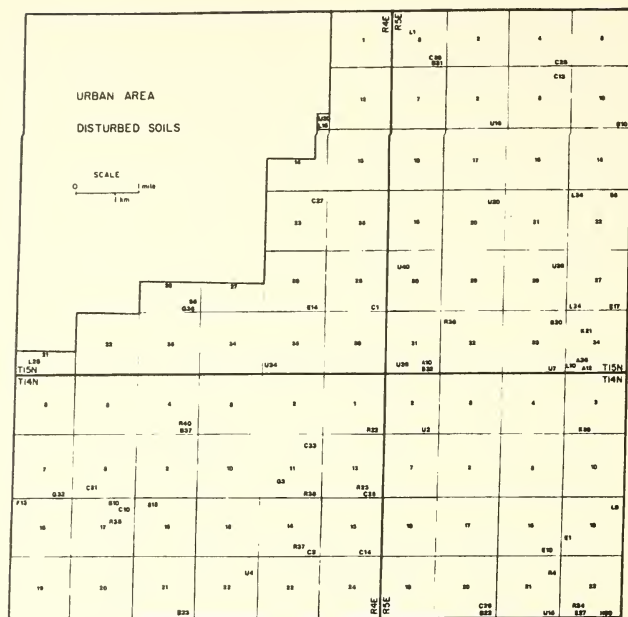


Figure 5. Southeast quarter of Marion County showing soil sample sites; B = Brookston; C = Crosby; R = Crosby-Miami; E = Eel; F = Fox; G = Genesee; H = Hennepin; A = Martinsville; U = Miami; K = Ockley; S = Shoals; L = Sloan; T = Westland.

MATERIALS AND METHODS

At least 30 samples were collected from each of the 13 soil types that cover most of Marion County. The sample sites were chosen with the aid of a computerized random-number generator.

To collect the soil gas, an 8 mm diameter hollow steel probe was pounded into the soil to a depth of 75 cm and then covered with a rubber septum. Three 10 cc samples of soil gas were drawn at each site by inserting hypodermic syringes through the septum. At some of the sites, a soil gas sample could not be collected at this depth, because the soil was too impermeable or too wet at 75 cm. In these cases, samples were collected at shallower depths.

Each sample was stored for at least one hour before analysis to ensure that only 222-Radon was present in the sample. No trace of 220-Radon would remain, because this gas has a half-life of less than one minute. An EDA RD-200 alpha scintillometer with removable phosphor-coated cells was used to analyze each sample. The counting method was similar to that of Reimer (1990), who had similar equipment.

RADON VALUES IN THE SOILS

The radon levels ranged from 0 to 4650 pCi/l (picoCuries per liter) in the thirteen soil types (Table 2). The sample sites covered approximately 72 percent of Marion County. An analysis of variance run on the radon values in the different soil types showed no statistically significant relationship for the arithmetic mean

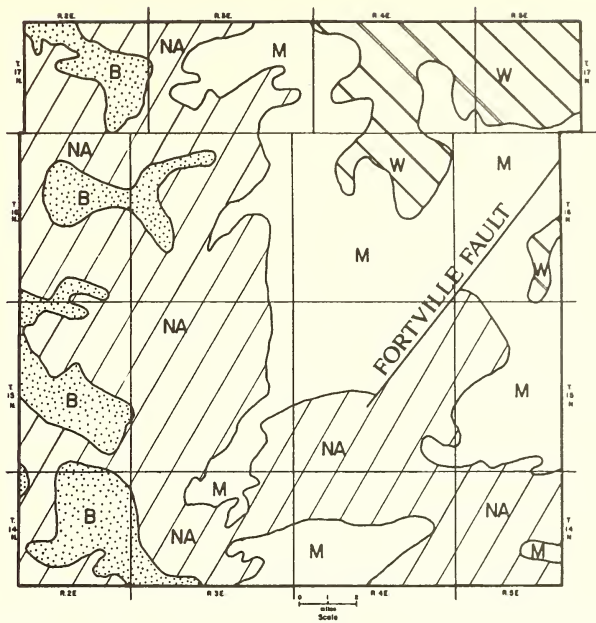


Figure 6. A revised geologic map of Marion County based on data from Gray, *et al.* (1987) and the soil radon data in this report; B = Borden Group; NA = New Albany Shale; M = Muscatatuck Group; W = Wabash Formation. The northeast trending line in Townships 15N and 16N is the trace of the Fortville Fault.

($F = 1.264$; $df = 12,420$; $P = 0.2211$) or the $\ln$ transformation ($F = 0.954$; $df = 12,420$; $P = 0.5036$) of the soil radon data. The soils types were combined into five groups based on their mode of formation: 1) broad till plains, 2) old glacial drainage ways, 3) well-drained outwash plains, 4) modern floodplains, and 5) steep slopes and escarpments. An analysis of variance run on these five groups associated by soil origin failed to reveal a statistically significant relationship within the data both for the arithmetic mean ($F = 0.832$; $df = 4,420$; $P = 0.5050$) and the $\ln$ transformation ($F = 0.934$; $df = 4,420$; $P = 0.4439$).

RADON VALUES OVER BEDROCK UNITS

Table 3 summarizes the radon values in the soils directly over the different rock formations in Marion County. Gray, *et al.* (1987) used a considerable amount of well log data to produce the Bedrock Geologic Map of Indiana. There is no reason to doubt the overall validity of their map. However, the radon values appear to indicate that there are definite areas of high and low radon levels which do not correspond to any particular soil type. The 272 sites in Table 3 represent approximately 56 percent of the sample sites. This subset of the data represents the sites where both the Indiana Geological Survey Map and the author agree that the bedrock is the same. Analysis of variance of the radon levels at these sites shows statistically significant relationships for both the arithmetic mean ($F = 38.597$; $df = 3,271$; $P < 0.001$) and the $\ln$ transformation ($F = 29.293$; $df = 3,271$;

$P < 0.001$) of the data. This subset of the data showed that bedrock was the factor controlling soil radon levels in Marion County.

Table 4 summarizes the data for all 484 sample sites based on the author's re-interpretation of the bedrock formation found under each sample site based strictly on soil radon levels. The author believes that the underlying bedrock has a greater effect on soil radon levels than the soil type itself. Further, the bedrock units can be mapped using the soil radon levels. Analysis of variance on the radon levels at these sites over the four different bedrock types indicated a statistically significant relationship between both the arithmetic mean ($F = 85.922$; $df = 3,483$; $P = 0.0$) and the $\ln$ transformation ($F = 61.237$; $df = 3,483$; $P = 0.0$) of the data.

The rate of movement of soil radon either in the gaseous phase or dissolved in water is related to the porosity and permeability of the regolith on top of the bedrock. This study was not designed to measure porosity or permeability at the collection sites. Typically, 100 feet of glacial deposits cover the bedrock in Marion County. In some of the river valleys, the overburden averages 50 feet, while on the outwash plains, the overburden may be 200 or more feet in thickness.

CONCLUSIONS

Figure 6 is a revised bedrock map for Marion County, based primarily on the Indiana Geological Survey Bedrock Map (Gray, *et al.*, 1987). Some formation contacts have been redrawn based on soil radon levels found during this study. The soil radon levels could be used to plot the contacts between bedrock units, if there was a significant difference in the amount of radioactive material in each of the bedrock units that were in contact. In this study, the two highest radon-producing units (the New Albany Shale and the Wabash Formation) are separated by two low radon-producing units (the Borden Group and the Muscatatuck Group).

The bedrock might well control soil radon levels in unglaciated terrain, where the soils developed from the underlying bedrock over a long period of time. In Marion County, the soils did not develop from the underlying bedrock but were formed from the glacial materials deposited by the melt waters of retreating Wisconsin glacial ice. To be controlled by bedrock, the radon must travel upward from the bedrock through the regolith in a relatively short period of time, since the half life of 222-Radon is approximately 3.8 days. The transport mechanism is undoubtedly based on a complex interacting set of factors in the bedrock units and the regolith.

ACKNOWLEDGMENTS

Field equipment was partially funded by a University Research Operations Committee (UROC) Grant from Indiana University Bloomington and Indiana University Kokomo. Indiana University Kokomo also provided some travel funds through a Grant-in-Aid-of-Research. Dr. Terry Zollenger, School of Public and Environmental Affairs, Indiana University-Purdue University, Indianapolis, made helpful suggestions on the statistical sampling method used in the field work. Dr. Ingrid Ritchie, also of the School of Public and Environmental Affairs generously gave her time to do the statistical analysis of the data.

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THE INDIANA ACADEMY OF SCIENCE AND THE EARLY PRESERVATION OF NATURAL AREAS

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ABSTRACT: The Academy's original Natural Areas Preservation Committee (1953-56) laid the groundwork for preserving the Pine Hills tract in southwestern Montgomery County. Due to the Committee's effort, The Nature Conservancy organized an Indiana Chapter in 1959. Pine Hills was the first project of this Chapter, and the project's success provided the stimulus which led to the establishment of the Division of Nature Preserves in the Indiana Department of Natural Resources. The idea to establish the Division of Nature Preserves was first, and effectively, proposed in May 1964 by an Academy representative (Alton A. Lindsey). Members of the Indiana Academy of Science worked both inside the Academy and independently toward setting up the Indiana Dunes National Lakeshore. They also provided the scientific survey data that were used to justify protecting the valleys of Sugar Creek and Big Walnut Creek from planned impoundments.

KEYWORDS: Division of Nature Preserves, Ecologists Union, Hasselman family, Indiana Academy of Science, Indiana Dunes National Lakeshore, Nature Conservancy, Nature Preserves, Pine Hills, pioneer preservationists, and State Parks.

INTRODUCTION

The preservation of small natural areas in the United States is the result of a socio-political-scientific movement of which the broader currents were initiated and guided by a few outdoor scientists and pushed to spectacular success by many people of a more pragmatic nature.

The unwisely named Ecologists Union was organized in 1945-46 as an activist offshoot of the Ecological Society of America. In 1951, urged by its Executive Director, botanist George B. Fell, the Ecologists Union changed its name to The Nature Conservancy, and the spectrum of its membership began to broaden. The Indiana Chapter did not exist until 1959, but six years earlier the Indiana Academy of Science had set up an equivalent agency.

The Academy's Centennial Volume, *History of the Indiana Academy of Science* (Daily and Daily, 1984), does not mention the Natural Areas Preservation Committee or its work for dates earlier than 1968, thus omitting its productive original period. The present writer, who organized and chaired the first such committee and is now its only survivor, is placing on record this first-hand account of early preservation history.

PINE HILLS, THE FLAGSHIP NATURE PRESERVE

Pine Hills was the first Nature Conservancy project in Indiana. This project was the reason why the Indiana Chapter of TNC was established, and later it led to the creation of the Division of Nature Preserves in the Indiana Department of

Natural Resources. Therefore, the Pine Hills story covers the initiation of both the systematized private and official actions in this field.

Since 1911, 600 acres on Sugar Creek upstream from the 1878 covered bridge on SR-234 had been owned by the Hasselman family of Indianapolis. Meanders of Clifty Creek and Indian Creek as well as a stretch of Sugar Creek had cut deeply into the Mississippian sandstone to form four precipitous "backbone" ridges and two more obscure ones, each rimmed with white pines and hemlocks. From reading the publications by Friesner and Potzger (1933) and McCormick (1962) as well as through leading Purdue plant ecology field trips there twice yearly since 1947, Alton A. Lindsey (1969) came to value the Pine Hills area very highly. Primarily to protect this one tract "in perpetuity," he induced the Indiana Academy of Science to establish on 15 May 1953 (Daily, 1954, p. 10) a Natural Areas Preservation Committee and served as its Chairman until its temporary dissolution four years later. Other members of the original Committee were Richard A. Laubengayer, botanist of Wabash College, J.O. Cottingham, real-estate professional and amateur mycologist, and Kenneth Shockley, an attorney.

Considering that there was no Indiana Chapter of TNC, that only about 17 Hoosiers belonged to TNC, and that the Army Corps of Engineers had threatening designs on Sugar Creek Valley, the Academy approved the Committee's recommendation to buy and maintain a few "model" natural areas for preservation, science, and education. On 14 October 1954, the Academy also advanced the Natural Areas Preservation Committee from a temporary (special) committee to a standing (permanent) one and authorized (without any appropriation) the Committee to raise funds through gifts solicited from Academy members and the public (Daily, 1955, p. 15). No Academy money was ever allocated for the Committee's work, and, as it turned out, the Committee members never claimed or received reimbursement for travel and other expenses.

Of the Hasselmans, only elder brother Victor remained in Indiana by 1953, and his health was precarious. When the Committee Chairman first talked with him, the family was unwilling to sell Pine Hills. However, after several visits, the family set the price at \$40,000. After further visits, the family became so enthused at the prospect of preservation that the price went down to a nominal \$15,000 for the 600 acres. Cottingham's search yielded 17 abstracts for the land parcels which the Hasselmans had combined into the Pine Hills property.

In 1954, Helmut Kohnke and Alton Lindsey invited TNC chief George Fell to Indiana and showed him a few natural areas. In 1955, the Lindseys had George and wife Barbara as house guests. Miss Barbara Garst had been an undergraduate in Lindsey's plant ecology course at the University of New Mexico in about 1946. After their marriage, the Fells had worked, more than merely full time, without any salary for three years, building up the Ecologists Union and its successor The Nature Conservancy.

After the four of us spent 20 September 1955 at Pine Hills (letter from George B. Fell of 1 July 1980 to A.A. Lindsey), TNC agreed to take Pine Hills on as a high priority project. The next day the Fells took our abstracts and an attorney to Victor Hasselman and obtained an option to purchase. (Also, that day in Indianapolis, we four attended the funeral of John E. Potzger, eminent ecologist of Butler University.)

By this time, opposition to this project had developed within the group's leadership, some of whom considered it inappropriate for the Academy to own land. In 1956, the Executive Committee (Daily, 1957, p. 8) unexpectedly appointed Alton Lindsey as the Academy's representative "for Pine Hills of the Nature Conservancy." Otherwise, the natural or scientific areas committee was dissolved (Daily, 1956, p. 15).

To enable TNC to acquire property in this State, an Indiana Chapter was required. By 14 July 1959, the national organization counted 39 members living in Indiana (TNC, unpublished report). With these as charter members, Dr. Lynton K. Caldwell of the Government faculty at Indiana University organized the Indiana Chapter and became its first Chairman. Twenty-one of the original members were college or university science professors. Along with Caldwell at Indiana University were James Canright, Charles B. Heiser, Jr., and Barbara Shalucha. Botanists John F. Pelton and Mrs. Jeanette S. Pelton represented Butler University. At Purdue were Durward L. Allen, Irving W. Burr, David H. Dunham, Clarence J. Goodnight, Helmut Kohnke, Alton A. Lindsey, M. Guy Mellon, and S.A. Rifenburgh. At Notre Dame University were Cornelius Hagerty and Robert P. McIntosh. At Wabash College was Richard Laubengayer; at Valparaiso University, Milferd H. Eggerding; at Manchester College, Philip Orpurt; at Marion College, Margaret Hodson; and at Earlham College, W.D. Dennis. Among the non-academic founders were Mrs. Eli Lilly, who had become a life member of TNC in 1956, and Martha Mosier Reynolds, whose son David, a judge, was to serve as President of the Indiana Chapter in the 1970's. Though not listed as Chapter founders, Howard Michaud of Purdue and Reynold Carlson of Indiana University had long been teachers of preservation.

About 1958, the late Dr. Jack McCormick, an Ohio ecological consultant who had in youth been a summer naturalist at Shades State Park, accepted the unpaid task of obtaining the funds for TNC to buy Pine Hills (about \$15,000, or \$10,000 plus enough to retire the mortgage), most of which he raised. The Indiana Chapter raised a fraction from its own members and the public. In 1960, the Indiana Chapter bought the tract, except for the 20 (?) acres near the covered bridge, owned by Wabash College and including Hemlock Lodge, which was still standing then.

One day in 1960, this writer was on a hike alone through apparently deserted Pine Hills, privately celebrating the long-sought change of ownership. While entering the scenic portion at Turkey Backbone, he unexpectedly encountered the departing Dr. and Mrs. Jack McCormick, who had driven from their Columbus, Ohio, home for the same purpose.

Academy President Carrolle Markle restored the Natural Areas Preservation Committee in 1966 after a decade's lapse, appointing as Chairman the late Robert Owen Petty (1966), plant ecologist of Wabash College (Dineen, 1967, p. 20). During his long tenure, he was active in behalf of Big Walnut, Pine Hills, Beckville (Calvert-Porter) Woods, Caster's Woods, Rush Woods, and Allee Memorial Forest. Petty wrote in 1980 that he went to Indianapolis in 1974 and placed the transfer papers for Wabash College's donation of 20 acres of Pine Hills into the hands of Natural Areas Division Director William Barnes (annotation on a copy of a letter dated 13 February 1969 from Lindsey to The Nature Conservancy's Washington office regarding Wabash College's 20 acres).

The importance of the Pine Hills Nature Preserve (Figure 1) is shown by the number of formal dedicatory gatherings held there over the years. The first of these was part of a national TNC and American Institute of Biological Sciences annual meeting held at Purdue University. On Sunday, 7 August 1961, Alton Lindsey led a joint field trip through the new preserve, during which the national TNC officers held a religious service dedicating it on the broad forested summit of Pine Backbone. On 16 October 1961, civil dedication ceremonies were sponsored by the State Department of Conservation. In 1970, the Department of Natural Resources dedicated the Preserve as a National Natural Landmark, jointly with the National Park Service. On 23 April 1990, the Department of Natural Resources celebrated the Preserve's first 30 years, rededicating it with a ceremony and tour. Attendance was by invitation to those with the most long-term connection with it. One speech was by Matthew Welsh, who as Indiana's Governor had spoken at the State Department of Conservation's dedication on 16 October 1961.

ORIGIN OF THE DIVISION OF NATURE PRESERVES

The Nature Conservancy donated Pine Hills preserve to the State in 1961, when the State Parks Division began managing the first State Nature Preserve. This arrangement was and still remains workable in this specific case, because Pine Hills adjoins Shades State Park, personnel of which occupy a house across SR-234 from Pine Hills. However, A.A. Lindsey considered this a poor precedent for future state nature preserves, few of which would be close enough to a state park for supervision and management. Hence, he wrote on 30 May 1964 to environmental activist Thomas E. Dustin, an advertising executive of Fort Wayne, proposing that Dustin persuade conservation groups to push for a new agency in our state government to handle nature preserves only, since their main purpose differs from that of recreationally oriented parks.

Under the letterhead of the State Chapter of the Izaak Walton League, of which Dustin was secretary, he replied on 10 June 1964 as follows (pers. comm. with A.A. Lindsey): "Dear Alton: In regard to your recent question on whether or not I am in a position to urge establishment of a state natural preserves commission, the answer is yes; however, I am just slightly backlogged at the moment. The idea sounds just great, and might serve as a counterbalance to some public and private bodies which fail to recognize the long-term values of setting aside some of our most outstanding natural areas for permanent protection. As soon as the smoke clears a little, I'll run the idea up a few flagpoles, and see who salutes."

As a result of Dustin's vigorous effort, including his enlisting Fort Wayne attorney James M. Barrett III, a member of the IWL and ACRES Inc., to write the legislation, Act S. 176 was approved on 11 March 1967. It created a Division of Nature Preserves within the DNR and set up an official system of State Nature Preserves.

On 14 February 1968, the DNR shifted William B. Barnes from its Fish and Wildlife Division to become the first Director of its new division. Throughout his first year in the post, Barnes was on salary but had no appropriated funds for running an office or to cover his work and travel expenses. His tenure was otherwise very effective and continued until his retirement in 1977.

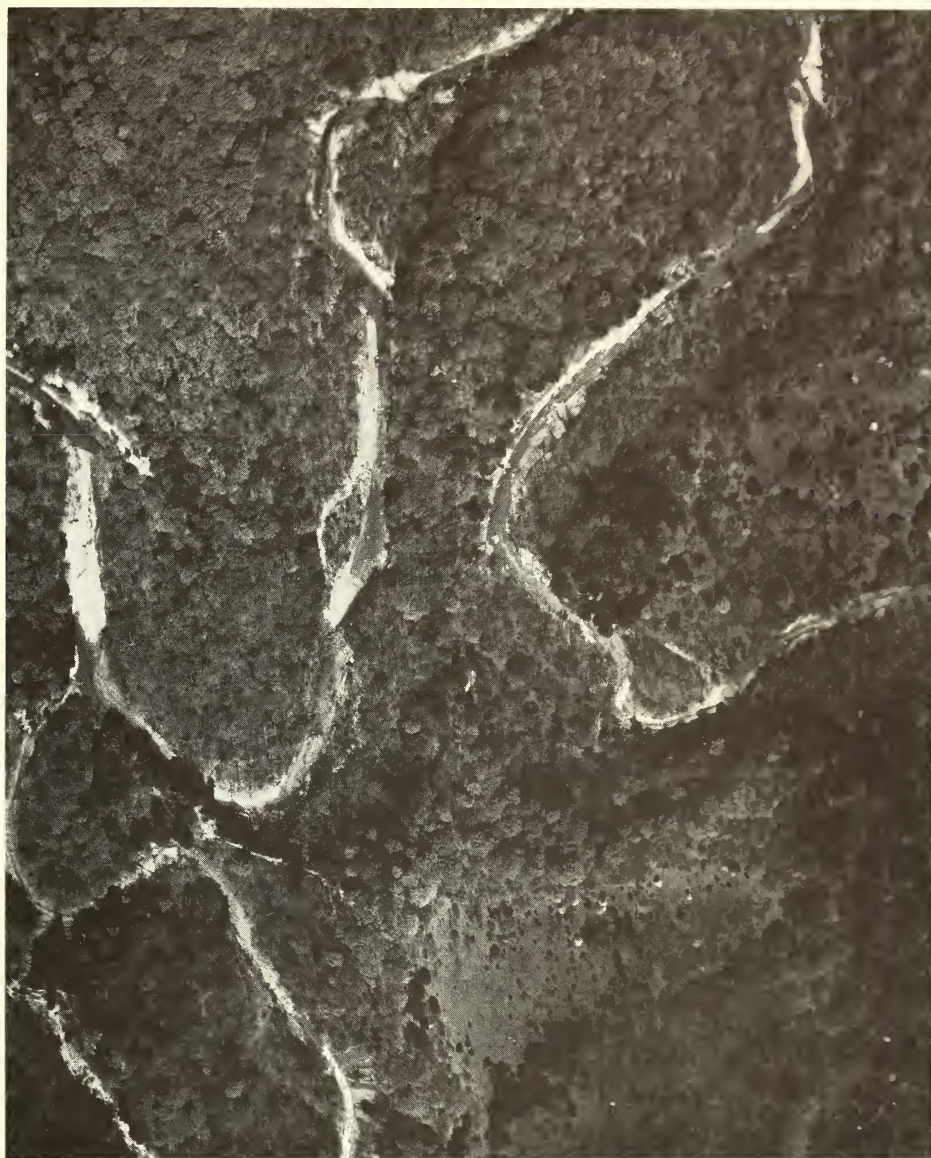


Figure 1. Vertical airphoto of central Pine Hills in about 1950. At the top (north), Indian Creek loops around to form Pine Backbone (center). Clifty Creek turns back toward itself (lowermost left) to form Turkey Backbone. The trail along its crest does not show here, but runs across the light-toned, nearly bare steep-slope swath at a right angle. The best known feature, Devil's Backbone, is where the sharpest bend of Clifty Creek closely approaches Indian Creek. The trail atop the caprock of Devil's Backbone leads eastward up a steep slope before, hidden by trees, it veers northward along the ridge of Pine Backbone. The fine old-growth beech and sugar maple stand in Pine Hills is on the second-terrace within the northern loop of Indian Creek. Well outside the photograph to the left, Indian Creek joins Sugar Creek, no part of which is shown.

THE INDIANA DUNES NATIONAL LAKESHORE CONTROVERSY

The scope of the sandstorm over the proposal for a National Lakeshore in the Lake Michigan dunelands in Indiana is shown by the present 71.5 feet of shelf-length of papers about it in the Calumet Regional Archives in Gary.

Academy members served as scientific advisors to the Save-the-Dunes Council (of which Dustin was the public-relations volunteer). The advisors mobilized the scientific community of the State and the national Ecological Society of America. The Ecological Society and the Indiana Academy of Science made and publicized their endorsements, the first time either group had taken an official position in a political controversy. The signatures of several hundred scientists were used effectively in the U.S. Congress. The National Park Service printed the Academy's statement on the front cover of its Lakeshore publicity brochure.

Without knowing that Rachel Carson was dying of cancer, the Council requested and received a letter of support from her. Especially helpful was a strong and heart-felt endorsement by Nobelist James D. Watson, whose start in biology had come as a serious young naturalist of Chesterton, Indiana, exploring the nearby dunes area for birds and trees.

LEADING PRESERVATIONISTS IN THE SIXTIES

Following the 39 charter members of the Indiana Chapter of The Nature Conservancy during the 1950's, these additional persons were among the leaders in the preservation of Indiana's natural areas during the 1960's (as were others mentioned herein whose names need not be repeated): Ethyle B. Block, Jane Dustin, Clarence W. Efroymsen, Henry Gray, Irene Herlocker-Meyer, Marion T. Jackson, Rev. John Klotz, Robert Menke, Fred Meyer, Victor Riemenschneider, Lee A. Rieth, Mary Jane Rieth, Richard O. Ristine, Forest Stearns, Sylvia Troy, Robert Weber, J. Dan Webster, Dennis Wolkoff, and Lester Zimmer. Most were members of the Indiana Academy of Science.

ADVISORY SERVICES INCLUDING PRESERVATION

In 1971 and 1972, the Academy supported an office in downtown Indianapolis and employed Dr. Helmut Kohnke, newly retired from Purdue, to work there several days a week to improve access by governmental and business groups to scientific and conservation information. Again, the Academy's otherwise excellent Centennial Volume makes no mention of this activity.

The Nature Preserves Act of 1967 stated that the current Academy President shall be our representative to the State Natural Resources Commission. In 1971, the Academy stimulated a change in the law so as to have a continuing member of that Commission, who would be better qualified in this field than most Academy Presidents. Since 1975, Fr. Damian Schmelz, Provost of Saint Meinrad College, has served the Academy and the public in this capacity.

A number of other effective preservation organizations and facilities were active within the time frame of this paper. However, they did not have sufficient direct contact with the Indiana Academy of Science to be discussed herein.

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HISTORY AND STATUS OF HERPETOLOGY IN INDIANA

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ABSTRACT: The first scientific collections and observations of Indiana amphibians and reptiles were made near New Harmony during the period 1825 to 1839. Virtually no additional work was done until the establishment of the Indiana Academy of Science in 1885. In the decade that followed, two accounts of the amphibians and reptiles of the State were published as well as several additional papers dealing with the Indiana herpetofauna. Herpetological studies concerning the Indiana fauna during the first 60 years of this century were largely confined to short papers treating local faunas or recording casual observations. In the past three decades, interest in amphibians and reptiles has increased at both the professional and amateur level. An updated account of the amphibians and reptiles of the State appeared in 1972. Currently, research projects involving amphibians and reptiles are being earned out at many of the State's universities and colleges as well as at zoos and museums. An active and growing group of amateur herpetologists in the State have formed a society of their own.

KEYWORDS: Indiana herpetology, Indiana type localities, herpetology history, New Harmony, O.P. Hay.

In his 1887 account of the amphibians and reptiles of Indiana, Oliver P. Hay evidently felt a need to apologize for offending public taste when he said, "Briefly let us consider ... why these animals should receive our attention. 'Reptiles' are to most people objects of supreme disgust, and such persons can not conceive why anyone should study them or do anything else with them except destroy them from the face of the earth." Hay would be surprised to find that about a century later 17 species of Indiana amphibians and reptiles, including three of four species of venomous snakes, receive legal protection in the State. However, he would also find that many species plentiful in his day are uncommon today.

The earliest accounts of Indiana reptiles come from travelers' tales and county histories and usually only mention poisonous snakes. In an account of travel in the State in 1816, David Thomas (1819) said that his host near Salem was recovering from the bite of a copperhead, and he mentioned several other species of snakes that were found near Vincennes. Another visitor to Vincennes wrote (cited in Hopley, 1882), "I have seen on a very warm and bright day such numbers of water vipers twined round the limbs and trunks which margin the pond that it would be almost impossible to wade a yard without being in reach of one of them... The inhabitants say, however, they are harmless." In 1825, about seventy rattlesnakes were killed in one day near Paul's Mill in Decatur County. "This was considered rather better than an ordinary day for snakes" (Harding, 1915).

Although the Ohio River politically belongs to Kentucky, it shares a biota with Indiana, and a characteristic American salamander, the mudpuppy (*Necturus maculosus*), was described from the Ohio by Constantine Rafinesque (1818), probably from near the falls at Jeffersonville. Rafinesque was a brilliant naturalist with a mania for describing new species. He also was apparently not a very critical observer, for he (Rafinesque, 1820) described *Necturus phosphoreus* as

Table 1. Reptiles and amphibians originally described from localities (type localities) in Indiana.

Original Name	Author	Type Locality	Present Name
<i>Amblystoma fuscum</i>	Hallowell, 1858	Hanover College	<i>Ambystoma jeffersonianum</i>
<i>Amblystoma copeianum</i>	Hay, 1885	Irvington, Marion County	<i>Ambystoma tigrinum</i>
<i>Amblystoma microstomum</i>	Cope, 1861	Wabash River	<i>Ambystoma texanum</i>
<i>Eurycea longicauda pernix</i>	Mittleman, 1942	Brown County State Park	<i>Eurycea l. longicauda</i>
<i>Eurycea bislineata rivicola</i>	Mittleman, 1949	McCormick's Creek State Park	<i>Eurycea cirrigera</i>
<i>Gyrinophilus maculicaudus</i>	Cope, 1890	Brookville, Franklin County	<i>Eurycea lucifuga</i>
<i>Bufo hobarti</i>	Sanders, 1987	Shades State Park	<i>Bufo woodhousei fowleri</i>
<i>Hyla triseriata</i>	Wied-Neuwied, 1839	Rush Creek, 4 miles south of New Harmony	<i>Pseudacris t. triseriata</i>
<i>Rana circulosa</i>	Rice & Davis, 1878	Benton County	<i>Rana areolata circulosa</i>
<i>Emys pseudogeographica</i>	Gray, 1831	Wabash River at New Harmony	<i>Graptemys pseudogeo- graphica</i>
<i>Emys lesueuri</i>	Gray, 1831	Wabash River at New Harmony	<i>Graptemys pseudogeo- graphica</i>
<i>Emys labryinthica</i>	LeSueur, 1851	Wabash River at New Harmony	<i>Pseudemys concinna hieroglyphica</i>
<i>Emys elegans</i>	Wied-Neuwied, 1839	Fox River at New Harmony	<i>Trachemys scripta elegans</i>
<i>Chrysemys marginata</i>	Agassiz, 1857	Restricted to "northern Indiana" by Schmidt, 1953	<i>Chrysemys picta marginata</i>
<i>Trionyx spiniferus</i>	LeSueur, 1827	Wabash River at New Harmony	<i>Apalone s. spinifera</i>
<i>Trionyx ocellatus</i>	LeSueur, 1827	Wabash River at New Harmony	<i>Apalone s. spinifera</i>
<i>Gymnopus olivaceus</i>	Wied-Neuwied, 1865	New Harmony	<i>Apalone s. spinifera</i>
<i>Trionyx muticus</i>	LeSueur, 1827	Wabash River at New Harmony	<i>Apalone m. mutica</i>
<i>Eutaenia sirtalis graminea</i>	Cope, 1888	Brookville, Franklin County	<i>Thamnophis s. sirtalis</i>
<i>Eutaneia radix melanotaenia</i>	Cope, 1888	Brookville, Franklin County	<i>Thamnophis r. radix</i>
<i>Eutaenia butleri</i>	Cope, 1888	Richmond, Wayne County	<i>Thamnophis butleri</i>
<i>Ophibolus getulus niger</i>	Yarrow, 1882	Wheatland, Knox County	<i>Lampropeltis getula nigra</i>

"Another species from the Ohio, its gills shine in the night of a fiery red colour." From other localities, he described three other well-known Indiana species — the red-spotted newt (*Notophthalmus viridescens*), the cave salamander (*Eurycea lucifuga*), and the massasauga (*Sistrurus catenatus*).

Like so much of Indiana history, herpetology has its roots in New Harmony, where the ideal community envisioned by Robert Owen attracted a group of brilliant naturalists. Here, between 1825 and 1839, the first significant scientific observations on reptiles and amphibians were made. Eight species of turtles, four currently valid, were first described from this area (Table 1). Included are Indiana's two species of softshells, *Apalone spinifera* and *A. mutica*. Most were obtained by Charles Alexander LeSueur, better known for his work in ichthyology and Australian natural history. However, Prince Maximilian zu Wied-Neuwied described a turtle destined for world notoriety, the red-eared turtle (*Trachemys scripta elegans*). This attractive and plentiful turtle became extremely popular in the pet trade beginning in the 1930's. Millions of juveniles were sold in the United States until 1975, when sales were stopped for health reasons. However, many red-eared turtles are still exported to nations not having such legislation. As a result of released pets, the red-eared turtle now has populations throughout the globe. Prince Maximilian also described from New Harmony one of the most frequently heard frogs of Indiana, the striped chorus frog (*Pseudacris triseriata*).

Interest in herpetology in Indiana seems to have been at a low level from 1840 until the founding of the Indiana Academy of Science in 1885. Although some individuals, such as James Sampson of New Harmony, Robert Ridgeway of Wheatland, Edward Hughes and Amos Butler of Brookville, and Barton Evermann of Terre Haute, made collections, only Ridgeway's specimens, now in the National Museum of Natural History, seem to have survived.

The first comprehensive account of the amphibians and reptiles of Indiana was that of Oliver P. Hay (1887a), then professor of biology and geology at Butler University. Shortly after the founding of the Indiana Academy of Science, he was appointed curator of herpetology. Later, he (Hay, 1892a) wrote a revised and more extensive account published by the Indiana Department of Geology and Natural Resources. He listed 81 species recorded from the State and an additional 25 species suspected to occur. He also recorded his observations on the natural history of Midwestern amphibians and reptiles. In separate papers, he reported on the habits of the massasauga (Hay, 1887b), one of the first life history studies of a rattlesnake, and on reproduction in Midwestern snakes (Hay, 1892b).

Willis S. Blatchley (1891, 1900, 1901), one of Indiana's most versatile and prolific naturalists, published several short papers on Indiana amphibians and reptiles. He also described the distinctive red cheeked salamander of the Smoky Mountains giving it the name *Plethodon jordani* in recognition of the Indiana Academy of Science's first President. Although Indiana University's distinguished zoologist Carl Eigenmann was not a herpetologist, his interest in cave fish led him to investigate cave salamanders.

Through the first sixty years of this century, most herpetological studies in Indiana were confined to local faunal lists and the records of casual observations. Among them were faunal lists and observations from the Indiana University biological stations near Mitchell (now Spring Mill State Park; Hahn, 1908) and

at Turkey Lake (now Lake Wawasee; Atkinson, 1896; Reddick, 1895) as well as the faunal survey of Lake Maxinkuckee (Everman and Clark, 1920). The herpetofauna of the Indiana Dunes region was initially investigated by Karl P. Schmidt, Walter Necker, and others from the Field Museum in the late 1930's (Pope, 1944), continued by Richard Edgren and W.T. Stille (Edgren and Stille, 1948; Stille and Edgren, 1948), and currently is being studied by Alan Resetar of the Field Museum. The activity of the Civilian Conservation Corps in Indiana during the 1930's was responsible for noteworthy herpetological papers by Chapman Grant (1936) and Paul Swanson (1939). M.B. Mittleman (1942, 1947, 1949), a herpetologist chiefly interested in salamanders, worked in Indiana during the 1940's. George S. Myers (1926) published a key to the amphibians and reptiles of the State listing 100 species. More broad-based studies such as those of Joseph Tihen on the Tertiary herpetofaunas of North America (1964) and James C. List (1966) on the osteology of leptotyphlopoid and typhlopoid snakes were also published. Minton (1972) lists other contributions from this era,

The author's first contribution to herpetology was an account of the reptiles of Indiana (Minton, 1944). The report was extremely amateurish and would never have seen print but for the kindness of Karl Schmidt, who felt deep concern for young herpetologists whose careers were being interrupted by the war. Later papers included a distributional study of amphibians and reptiles in Illinois and Indiana (Smith and Minton, 1957) and a report of some peculiarities in the systematics and life history of Jefferson's salamander in Indiana (Minton, 1954). This latter paper led to studies by Thomas Uzzell, then at the University of Michigan, indicating that Jefferson's salamander in the Midwest is a composite of two conventional species (*Ambystoma jeffersonianum* and *A. laterale*) and numerous female polyploid populations whose status remains unsettled (Uzzell, 1964; Morris and Brandon, 1984). The author's monograph on the amphibians and reptiles of the State (Minton, 1972) was based largely on field work done between 1947 and 1957 as well as between 1965 and 1970. The monograph listed 82 species making up the present fauna plus two extirpated and several doubtful species.

The 1970's saw an increase in interest in herpetology at both the professional and amateur level, partly due to a growing concern with the environment and a realization that amphibians and reptiles are sensitive indicators of environmental change. In addition, improvements in the techniques for studying natural populations of these animals had been developed and better methods for their husbandry had been found. Much current interest is centered on the decline in amphibian populations at the world and local levels. Michael Lannoo of Ball State University currently is U.S. Coordinator of the Declining Amphibian Populations Task Force. In 1984, the Nongame and Endangered Wildlife Program of the Department of Natural Resources established a Technical Advisory Committee to investigate the status of amphibians and reptiles in Indiana, to list species whose populations were especially at risk, and to make recommendations for their protection. This committee, now under the chairmanship of Daryl Karns, continues to monitor reptiles and amphibians in the State and to identify species needing special study and legal protection.

Research and teaching in herpetology are part of the curriculum at many of Indiana's universities and colleges. John O. Whitaker, Jr., and his students at

Indiana State University have carried out several studies on the life histories and feeding habits of amphibians. At Notre Dame, David Sever is working on salamanders, and at Earlham, John Iverson is working on a variety of herpetological subjects with emphasis on kinosternid turtles. Patricia G. Parker (1993) of Purdue recently reported on a study of genetic diversity in turtle populations using DNA fingerprinting. Stephen Perrill and his students at Butler University study anural vocalization and social behavior, and Daryl R. Karns and his students are involved in herpetological research projects at Hanover College. Craig Nelson (1993) reported on herpetological research at Indiana University, including the effects of temperature on sex determination in turtles, the structure of pond-breeding amphibian communities, and sensory specializations in amphibian and reptile behavior. Nelson, Michael Ewert, and their students have surveyed the herpetofauna of several areas in southern Indiana. The unique Axolotl Facility at Indiana University, established in 1957 by Rufus Humphrey, is being utilized for research on the regeneration of limbs, tissue transplantation, the biological basis for memory, and other projects. The Axolotl Facility supplies material for laboratories throughout the world. Work on amphibian and reptile ecology by Spencer Cartwright, William E. Cooper, Bruce Kingsbury, and Barry Sinervo is in progress at Bloomington and several regional campuses in the Indiana University System as well as by Robert Broadman at St. Joseph's College.

The Indiana State Museum has recently provided unique information on the State herpetofauna through the studies of J. Alan Holman and Ronald L. Richards (1993) on Pleistocene and Quaternary reptile remains from cave deposits and other sites. The museum also provides a repository for Indiana herpetological specimens. Julian Duval, formerly of the Indianapolis Zoo, and other herpetologists are carrying out studies on the biology and husbandry of West Indian iguanas (*Cyclura*), land tortoises, and other species.

Amateurs have always made major contributions to herpetology. Indeed, in American herpetology until about 1950, the line between amateur and professional herpetologists was tenuous. Angus Gaines, who published lists of the Knox County herpetofauna (1894-95), apparently was an early Indiana amateur who worked in a lumber yard for part of his life. The distinguished Indiana surgeon and astronomer, Goethe Link, was keenly interested in snakes and contributed many specimens collected near his home in Morgan County to the Chicago Academy of Science. Among amateurs now active who have contributed to our knowledge of the distribution and habits of Indiana amphibians and reptiles are Michael J. Lodato of Evansville, Dennis Brown of Indianapolis, and Paul Spicer of Fort Wayne.

The chief interest of many amateur herpetologists today is the husbandry and captive breeding of interesting and attractive species such as the tri-color kingsnakes, boas and pythons, leopard geckos, African chameleons, fire-bellied toads, and arrow-poison frogs. The Hoosier Herpetological Society, established in 1987 by a group of amateur herpetologists, includes both professionals and amateurs and contributes significantly to herpetological knowledge in the State and to the education of the public concerning reptiles and amphibians. After about a century and a half, the discipline of herpetology appears to be a respectable part of science in Indiana.

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ALFRED CHARLES KINSEY AS AN ENTOMOLOGIST

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ABSTRACT: A review of the entomological work of Alfred C. Kinsey shows that he was an innovator in the field of insect systematics as well as in the study of human sexual behavior. His principal works in entomology involved the Hymenopterous gall-making wasps of the family Cynipidae and their relatives. Among his innovations were his insistence on the use of a massive series of specimens over the widest possible geographic range and the use of all the genetic, physiological, geological, and other data available bearing on classification. His work on insects was widely recognized and appreciated before he began his seminal work on human sexual behavior.

KEYWORDS: Alfred C. Kinsey, Cynipidae, *Cynips*, evolution, Figitidae, higher categories, Hymenoptera, *Neuroterus*, T.W. Torrey.

INTRODUCTION

Alfred Charles Kinsey (1894-1956) was not satisfied to work and gain distinction in a single field of study. He was afflicted from youth with the Puritan work ethic which insists that man's purpose on earth is to work. Kinsey told several people that he came from a line of short-lived men and suspected he would not live long, and that he intended to do as much work as most men in the time he was allotted.

As a boy, he was active in the Boy Scouts of America and became a competent field naturalist. After graduating from Bowdoin and receiving a D. Sci. degree from Harvard, he moved to Indiana University, where he found a wife, Clara McMillan, and, eventually, recognition in two major areas of biology — systematic entomology and human behavior. Kinsey, even shortly before his death, insisted that he was actually a taxonomist working on a taxonomic problem in human behavior.

Kinsey worked diligently until he died. T.W. Torrey, longtime chairman of biology at Indiana University, told the author of a visit from Kinsey in 1956. Kinsey stopped by Torrey's office in regard to some business concerning the developing Sex Institute. As he was leaving, Torrey, concerned about Kinsey's apparent illness, suggested that Kinsey might take some time off from his work to recover. Kinsey replied, "Quit work? If I can't work, I'd rather be dead!" Torrey never saw him alive again.

Kinsey did not drink heavily or smoke. His favorite party joke was to approach someone with a martini and ask, "Does the ice water keep the olive fresh?" He once tried smoking, hoping that the habit might gain him more rapport with some of the people he was interviewing, but he was so inexperienced and erratic that he was asked to desist. During his last years, he began to take a Coca Cola in the afternoon, finding he could then work longer without getting sleepy. (For

more information on Kinsey's life, please refer to his obituary by O.B. Christy (1957).)

KINSEY'S WORK ON GALL-MAKING WASPS

During the period immediately following his work at Harvard University, Kinsey traveled widely in the United States on a Sheldon Traveling Fellowship, gathering much of the material on which he later based a major revision of the genus *Cynips*. Later, during his tenure at Indiana University, he made field trips to Mexico and Central America, usually accompanied by students. (One small insight into Kinsey's character comes from one of these later trips when Kinsey sent a student home for refusing to take a cold shower in the morning.) Kinsey, in his work on gall wasps, defined species as populations with a common heritage. He maintained that they were not merely mental concepts but realities which preserve a morphological and physiological identity under varying conditions over vast geographical areas. Species populations contain variations, mutations, and Mendelian races which may be, if isolated, the source of new species. Hybrid populations, although they occur, do not seem to have formed new species in *Cynips*. These conclusions were derived from the morphology, biometry, host relationships, life cycles, and geographic distribution of *Cynips*. Kinsey generally rejected what he called the Darwinian interpretation of the origin of new species through the accumulation of small variations. He also asserted that although species populations may show variation in some characters, large series will show great uniformity of characters. Much mystifying variation might be eliminated if larger series were used. There might also be uniformity in variation. Kinsey maintained that the higher categories were realities and not simply mental concepts convenient for sorting organisms. He felt that his work on gall wasps showed the reality of the higher categories. He summarized his thinking concerning higher categories and the taxonomic method somewhat as follows (1936):

1. Higher categories represent the ancestral stocks from which lower categories (the present day species) have been derived.
2. The ancestral stocks which gave rise to the higher categories were originally single species.
3. The higher category is of more ancient origin (in time) than any lower category.
4. The ancestral stocks representing the higher categories are for the most part extinct; only the products of evolution are available today.
5. Multiplication of species may be accomplished through isolation of portions of an older species and independent mutation and hybridization within each such isolated portion.
6. The higher categories are realities in nature; they were once real species.
7. Evolution has been radiate not linear.
8. The best representation of evolution, therefore, is of a "tree of life" in which the trunk represents ancestral stocks out of which the branches (lower categories) evolved.
9. The number and magnitude of characteristics common to any category depends on the age of the category.

10. Categorical rank is to be determined by the nature of the particular character involved.
11. Reproductive organs (primary or more often secondary) are more conservative than other characters and, therefore, have greater significance in establishing higher categories.
12. The adaptive nature of a character determines the categorical rank of the unit in which the character is found.
13. The capacity of two groups to hybridize is inversely related to the categorical rank.

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ON THE HUMAN CONDITION: COUNTDOWN TO 2015

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ABSTRACT: Many people are appalled by the reports of rampant death by disease and starvation that are coming from less-industrialized countries such as Rwanda or Haiti. Predictions of their occurrence started to appear in the scientific literature in the early 1960's. More recent studies have echoed these conclusions. In this paper, the development of increasingly sophisticated computer simulations of the future of humankind are discussed. The problems that these simulations point out have yet to be dealt with in an effective manner.

KEYWORDS: *Beyond the Limits*, famine, food shortages, *Global 2000*, *Mankind at the Turning Point*, overpopulation, starvation, *The Limits to Growth*.

INTRODUCTION

In 1992, two events occurred whose juxtaposition should have been the cause of great foreboding. US troops entered Somalia to aid in distributing food, and the twentieth anniversary of the publication of *The Limits to Growth*, a book dealing with the computer simulation of the future of humankind, was observed. The one event focused our attention on our fellow humans, while the other caused a brief ripple in the popular press and then faded from view. Why was the anniversary of the publication of *The Limits to Growth* and the release of its companion volume, *Beyond the Limits*, so widely disregarded?

One reason might be the way environmental science and ecology are taught. A large number of environmental science and ecology texts have been published in the last 25 years, but they rarely include a discussion of how the various environmental problems impact each other (e.g., Kupchella and Hyland, 1993; Smith, 1992; Stiling, 1992). Their coverage is limited to a topic by topic recitation of the woes of the world.

Another reason might be our own inability to face the issue squarely. Deciding to stand up for the rights of the spotted owl is quite easy in comparison to simultaneously facing a large number of interconnected problems, particularly if those problems must be related to our personal values, our accustomed lifestyle, societal standards, and the lifestyle we feel all people should have.

In this paper, six landmark publications dealing with possible human futures are reviewed in chronological sequence. As their authors have pointed out, the conclusions discussed here are not predictions. The authors of these books only discuss possible outcomes based on the data available at the time the books were written.

The conclusions expressed in this review are those of the books' original authors, presented as impartially as individuals who are concerned with their own and their children's futures can be. Our own opinions intrude largely in the closing summary. Unfortunately, the conclusions reached in all these texts are terrifyingly consistent. They must be confronted. This review will direct interested readers to

the relevant literature and allow teachers to introduce the fundamentals of ecological computer simulation into their classrooms.

FAMINE 1975!

The interrelationship between food supply and human population has been of continuing interest to ecologists, demographers, and conservationists for the last thirty-five years. Interest in this relationship was kindled by two books, *Hungry Nations* and *Famine 1975!* (Paddock and Paddock, 1964, 1967, 1976), which dealt with food production and re-emphasized the predictions made by Thomas Malthus (in Hardin, 1969, pp. 4-16) in "An Essay on the Principle of Population," which dealt with overpopulation.

The arithmetic increase in food production was juxtaposed with exponential population growth as an augur of starvation by Malthus in 1798 in response to the alarming population boom of the late eighteenth century (in Hardin, 1969, p. 15):

The happiness of a country does not depend, absolutely, upon its poverty or its riches, upon its youth or age, upon its being thinly or fully inhabited, but upon the rapidity with which it is increasing, upon the degree in which the yearly increase in food approaches to the yearly increase of an unrestricted population.

Malthus was largely forgotten, because the Industrial Revolution and the colonization of the Americas relieved population pressures on European food resources.

Malthus' dormant theme was taken up by William and Paul Paddock. These brothers, one an agronomist and the other a US Foreign Service Officer, wrote *Hungry Nations* in 1964 out of their personal experience and exposure to famine in the less-industrialized nations. The Paddocks felt that tangible resources (i.e., air, land, and water) determine a nation's wealth. The resource might be nonrenewable, like oil, or renewable but susceptible to erosion/exhaustion, such as the amount of arable soil. When a nation can produce a surplus of goods in excess of the needs of its populace by developing its tangible resources, it progresses. The root cause of poverty and starvation in the hungry nations is population in excess of resources.

The Paddocks warned against feeding hungry nations. If food is charitably shipped to meet a food emergency, then a larger population will have to be fed when the next "emergency" occurs. Since the American wealth that produces surplus food is not inexhaustible, America will not be able to feed the hungry nations forever. Food recipients must develop the ability to feed themselves.

The Paddocks note that agricultural research is not a luxury a hungry nation can do without. A region's agricultural development and production are shaped by its local environmental conditions. The detailed research that has led to the successful agricultural technologies of temperate North America is of little or no use in a foreign locale. Fortunately, if the hungry nation acquires the ability to feed itself, local agricultural research, although more difficult, more protracted, and more vulnerable to loss of funding than industrial research, will pay for itself.

Despite their initial optimism, the severity of the food-population imbalance escalated more rapidly than the Paddocks expected. In 1967, the Paddocks published *Famine 1975!*. In this work, they stated that inevitable famines were looming on the horizon due to the collision of exponential population growth with

stagnant food production. For the first time, America would have to choose amongst deserving recipients of food rather than just responding with gifts for everyone.

The Paddocks' method for choosing among food recipients was called "triage." Triage identifies three types of hungry nations. The "can't be saved" have populations that have already surpassed their agricultural potential. The "walking wounded" have the resources to produce or buy the needed food and, therefore, can cope with their population growth. The "walking wounded" should be able to correct their own problems. Nations "that should be helped" have a manageable degree of imbalance between food and population. They "should be helped" even though the imbalance is great, and they cannot be immediately expected to correct the imbalance by themselves.

Food aid to the nations "that should be helped" would allow dynamic local leadership sufficient time to initiate effective birth control practices and to proceed with agricultural research and development. America's responsibility would be to administer and enforce policies for self-reliant development in recipient nations. The recipient nation's responsibility would be to "pay for" that aid by participating in birth control programs and heavy agricultural investment.

TRAGEDY OF THE COMMONS

Many people rejected what the Paddocks said because they believed that a technological solution, requiring "...a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality" (Hardin, 1969, p. 367), was possible. Garrett Hardin (in Hardin, 1969, pp. 367-381) in his essay, "Tragedy of the Commons," showed that this belief was not valid. In a commons, it is in every man's best interest to maximize his use of a scarce resource at everyone's expense, including his own, because his loss is a lesser portion than his gain. "...freedom in a commons brings ruin to all" (Hardin, 1969, p. 371) and therein lies the tragedy. (The term "commons" referred initially to the pastureland available to English farmers for raising livestock. In America, the last great commons is our system of National Parks and Forests. Internationally, the last great commons is the sea. The fishing and whaling industries and their declining catch sizes are ample proof of the tragedy of the commons. The unregulated market system (the fishing industry) is rewarding the destruction of the resource held in the commons (the fish) on which it is based.) There is no technological solution to overpopulation. Freedom to breed will bring ruin to all.

THE LIMITS TO GROWTH

The authors of the previous books appealed to their readers' emotions to bring about change. A desire to project their conclusions into the future led to the introduction of the computer into the decision-making process. In 1972, *The Limits to Growth* (Meadows, *et al.*, 1972) was published by the Club of Rome, an informal, international group of businessmen and experts in various scientific fields. Their computer model (World3) was based upon five (actually six, if the service sector is considered) interconnected feedback systems modeling industrial-

ization, population growth, agricultural production, resource consumption, and pollution. All six systems were growing (and continue to grow) exponentially.

Using their computer model, the investigators reached three conclusions. First, a continuation of present trends would result in the world system's overshooting an upper limit (resource availability) sometime within the next century, after which a rapid and uncontrollable collapse (or crash) in industry and then population would occur. Technological advances would not prevent the collapse, because the interlocking feedback loops that make up the world system assure collapse even if only one limit is exceeded. Second, a state of global equilibrium could be achieved by lowering population growth rates, conserving resources, and emphasizing investment in agriculture and the service industries, but not in manufacturing consumer goods. When equilibrium is achieved, every person would have his/her basic needs met and would reach his/her full potential. Finally, the probability of success would decrease with each passing year, because the high rates of change insure that the world system would exceed a natural limit.

The Limits to Growth called for a radical reorganization of human society. Many people chose to reject it (Club of Rome, 1973). Such a highly aggregated (i.e., world) model could not provide a platform for policy change, because the projected trends would not occur with the same severity throughout the world. In addition, technological innovation and industrial growth continued to be touted by traditional economists. The model was too inflexible and could not account for the development of new technologies. (Countering these arguments is the fact that experience has shown that the biosphere is more sensitive to pollution than the model predicted.)

MANKIND AT THE TURNING POINT

These criticisms were addressed rather quickly in a second report, *Mankind at the Turning Point* (Mesarovic and Pestel, 1974). How did the new computer model differ from the one used in *The Limits to Growth*? The number of variables studied increased from a few hundred to over 100,000. The model was also regionalized to account for the political, cultural, and economic diversity of different parts of the world. Each region's development was then simulated at several levels, starting with the individual and ending with the ecosystem. Finally, societal and technological change could be injected into the operation of the model at any time. As a result of these changes, the different regions would face different crises at different times, and there was no dominant, single limit to the world system.

Food remained the most precious of resources. To allow any hope of success, massive investment and a transfer of all applicable technology from the industrialized into the less-industrialized countries would have to occur very early to close the food-supply gap and the import-export imbalance in the less-industrialized world. Regional populations would have to be stabilized. Due to the high rate of change, delay would reduce our options. A global approach would be necessary because all parts of the world system are ultimately interdependent.

The conclusions reached in *Mankind at the Turning Point* were basically the same as those reached in *The Limits to Growth*. The prescribed remedies, which

require a long-term commitment to change as well as a continuity in global leadership, must be implemented before the crises become apparent.

GLOBAL 2000

In 1977, President Carter focused the attention of the entire Federal Government on these problems for the first time. The Council on Environmental Quality and the Department of State were directed to cooperate with other government agencies to investigate possible changes in the world system through the end of the century. The result was *Global 2000: The Report to the President Entering the 21st Century* (Barney, 1980),

Global 2000 projected that the world's population would increase 55% to 6.35 billion by the year 2000, with 92% of the growth occurring in less-industrialized countries. Food production was projected to increase at a rate of 2.2% per year, paralleling the record increases recorded during the 1950's and 1960's (which included the high-yield grain varieties developed during the Green Revolution). By the year 2000, the number of people supported on 1 hectare of farmland in 1970 would have to increase from 2.6 to 4 people through an increased use of fertilizer, pesticides, herbicides, and irrigation (i.e., energy-intensive, yield-enhancing inputs). Per capita food consumption was projected to increase by 15% over this period. This increased consumption would occur in the already well-fed, industrialized nations. Overall, the number of malnourished people was projected to increase from half a million in 1970 to 1.3 billion in 2000.

When *Global 2000* was revised in 1988, the projected food yields were reduced to reflect diminishing returns from the use of energy-intensive, yield-enhancing inputs and a decline in the carrying capacity of the land. In its revised form, *Global 2000* reached the same conclusions as *Mankind at the Turning Point*; i.e., that a sustainable economy coupled with environmental protection, resource conservation, and limited population growth was imperative. "The needed changes go far beyond the capability and responsibility of this or any other single nation. An era of unprecedented cooperation and commitment is essential" (Barney, 1980, p. 4).

The government's conclusion, which required a global solution, was quite surprising, because their computer models were flawed. Although the individual agencies had access to vast amounts of information, each agency developed its own computer model. This made the simultaneous study of all factors by any agency impossible. Each agency also assumed that the inputs required by its model would be met irrespective of the results being obtained in other simulations. If all the models had been integrated, the projections in *Global 2000* would have been less optimistic. Integration would have intensified and hastened the consequences of the predicted trends.

BEYOND THE LIMITS

Beyond the Limits (Meadows, et al., 1992), the twentieth anniversary successor to *The Limits to Growth*, is the most recent, computer-generated assessment of the predicament of humankind. In this book, the authors return to a one-world simulation. They believe that humankind's approach to planetary limits must be

studied, because no nation is completely insulated from what occurs in the rest of the world.

Beyond the Limits concludes that conditions have not improved in the last 20 years. "The human world is beyond its limits" (Meadows, *et al.*, 1992, p. xv). Overshoot and erosion of the carrying capacity are the most likely outcomes of a continuation of current policies. To have a sustainable future, humankind must scale back its expectations.

The global economy called for in *Mankind at the Turning Point* has not developed. Continued growth has not solved the problems of poverty and unemployment. Between 1970 and 1990, industrial output grew faster than population, but most of the economic growth occurred in industrialized countries whose populations were approaching stability and where the economic base was already large. Basic needs were being met in these countries, resulting in high rates of savings and investment. In the less-industrialized countries, the rapidly growing populations consumed any economic gain so that poverty was perpetuated, fueling even greater population increases.

Agricultural output has increased by a factor of two to three and could adequately feed the world's population. In the less-industrialized countries, large population increases coupled with storage and distribution problems have kept food per capita low and largely unchanged. In Africa, food per capita is decreasing.

Without change, food will become the global limiting factor. The limits to food production are land, water, soil nutrients, and sinks for agricultural pollutants. Throughout human history, land has been abundant. Only in the last 35 years has exponential population growth led to a shortage. In some regions, these limits (e.g., water for irrigation) have been exceeded, and the agricultural base is being degraded; i.e., "...agricultural success has resulted primarily in more people and more deserts" (Meadows, *et al.*, 1992, p. 40). Yet, remedial conservation techniques, such as alley cropping and agroforestry, are known. The problem is not technical, but social. Societies have not implemented the solution.

The computer model in *Beyond the Limits*, World3/91, an upgraded version of the program used in *The Limits to Growth*, is based on four physical and biological limits: the amount of cultivatable land (3.2 billion hectares), the yield per land unit (6,500 kg grain/hectare), the nonrenewable resource supply (200 years at 1990 extraction rates), and pollution absorption (a variable which is difficult to quantify). The model has a strong tendency to overshoot and collapse due to the delays inherent in natural systems (e.g., pollutants become noticeably harmful only at sufficiently high concentrations) and the inability of these systems to repair themselves quickly, if at all, after severe degradation (e.g., since extinction is forever, what would a regenerated rain forest which had lost a significant number of its species look like?). Even these conclusions may be overly optimistic, because societal changes such as war, strikes, disease, trade embargoes, or political maneuvering are not accounted for in the model.

Hungry people tend to permanently degrade their environment (e.g., desertification and acidification). Delays in implementing new technologies are too long to prevent the degradation of the environment. Delays result in overshoot, and degradation results in collapse. The societies that are least capable of technological change are the ones that are impacted first.

These conclusions are summarized in the following statement (Meadows, *et al.*, 1992, p. 138):

Any population-economy-environment system that has feedback delays and slow physical responses, that has thresholds and erosive mechanisms, is literally *unmanageable*. No matter how brilliant its technologies, no matter how efficient its economy, no matter how wise its decision makers, it simply can't steer itself away from the hazards unless it tests its limits very, very slowly. If it constantly tries to accelerate, it is bound to overshoot. [emphasis in original]

To prepare, humankind must think decades ahead.

When deliberate constraints on growth are implemented by society (scenario 10 in *Beyond the Limits*), a sustainable equilibrium is possible. If implemented in 1995, this sustainable society would include 7.7 billion people with life expectancies of 80 years. Had these constraints on growth been implemented twenty years ago (1975), the world population would have stabilized at a lower number, allowing for more goods per capita, producing less pollution, and having more remaining nonrenewable resources. (Humankind will find it difficult, if not impossible, to return to this point.) If change is delayed until 2015, collapse can no longer be forestalled. The model cannot be used to study whether or not recovery would occur, because accurate point predictions about regions and times are not possible. Total collapse may be simply unavoidable.

The conclusions reached in *Beyond the Limits* mandate three actions. First, the consumption of material goods and energy must be scaled back, if the world system is not going to collapse. The world's sources of raw materials are drying up, and the world's sinks for waste disposal are overflowing. Second, as the rates of material consumption and population growth are decreased, the efficiency of material and energy usage must be increased. The emphasis will be on making durable goods and efficient machines. Third, global equilibrium can only be achieved if humankind emphasizes the equality of people and de-emphasizes the output of material goods (i.e., humankind must emphasize qualitative, or structural, improvement and not quantitative, or material, growth). Poverty must not be allowed to exist (also see Commoner, 1992) — "...society must provide material sufficiency and security for all" (Meadows, *et al.*, 1992, p. 211). As a result, technology and culture would bloom.

The major hurdles to implementing this system are political and psychological. A discussion of environmental issues is often avoided, because these issues are too politically and emotionally charged. Who is to blame? Who should take care of the problem? Meadows, *et al.* (1992, p. 191) note that:

The third way to respond [after denial and attempting to shore up the system] is to step back and acknowledge that the human socioeconomic system as currently structured is unmanageable, has overshoot its limits, and is headed for collapse, and, therefore, to *change the structure of the system*. [emphasis in original]

People are taught to consume and that growth is good. However, **more** is no longer better. We must decide when we have **enough** things and **enough** people and look forward to a period of global sustainability.

SUMMARY

As can be seen in this brief review, little has changed in the human condition over the last 20 to 25 years. The conclusions reached in each of these books still confront us. First, all the people of the earth must be respected and treated as members of a large interconnected family. Armed confrontation in the Near East, Yugoslavia, and Somalia show how far we are from achieving this goal. Second, a global economy must be developed that provides security for all people on all continents. Although painful, some jobs must be exported from the developed countries to help create a global economy. Third, economic growth is no longer a blessing. We should not worry excessively about the creation of new manufacturing jobs but look to the service sector. If growth is to occur in the service sector, the pay must be higher to prevent increasing the ranks of the working poor. Finally, educators must play an ever increasing role in fulfilling human potential. Teachers are going to be asked to make everyone happy and enlightened at a time when it is difficult to convince some students it is their best interest to study and to learn. Of course, all of these changes should be instituted by 1995.

These issues should not be introduced dogmatically into the classroom, because they represent only one point of view. An informal discussion of this manuscript in a class of upper division biology majors showed that a single, unanimous opinion is not possible. These topics do offer the possibility for some interesting debates from a position that is nearly always neglected in introductory textbooks. Global models provide a stimulus by which our students' growing environmental concerns can be elevated to a global level. When the students feel they can make a difference, they are empowered for change.

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EFFECTS OF RAINFALL AND TEMPERATURE ON WEIGHT GAIN IN THE BIG BROWN BAT, *EPTESICUS FUSCUS*

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ABSTRACT: Nineteen maternal colonies of the big brown bat, *Eptesicus fuscus*, were located and revisited several times in Delaware and Grant Counties from 21 May to 22 September 1992. Bats were captured, sexed, aged, weighed, and banded at each site. Rainfall in the summer of 1992 was below normal in May and above normal in June and July. Temperatures were below normal throughout the study period. The weights of the bats captured in 1992 were compared to the weights of the bats captured in the same area during the same time period in 1988 (a dry, warm year) and 1989 (a medium, wet year). Both 1988 and 1989 had near normal temperatures. Weights of juvenile bats trapped in the summer of 1988 were lower and showed a wider range in variation than those caught in 1989 and 1992. Lower weight gain for juveniles and adult females in the late spring and early summer of 1988 was associated with lower than average rainfall and higher than average temperatures during that period.

KEYWORDS: Big brown bat, *Eptesicus fuscus*, effect of rainfall on weight gain in bats, effect of temperature on weight gain in bats, weight gain in bats.

INTRODUCTION

This study is a continuation of one begun in 1988 by Howell (1990) on the effects of rainfall on weight gain in the big brown bat (*Eptesicus fuscus*). Howell's study included bats from Delaware, Grant, Blackford, Henry, Jay, Madison, and Randolph Counties in east-central Indiana and indicated a correlation between the amount of rainfall and the weight gain pattern of the bats. Weight gain in the dry year (1988) was lower than in the wet year (1989).

In 1992, only bats from Delaware and Grant Counties were studied. Most of Howell's data were from Delaware and Grant Counties, and these colonies could be relocated. The current study tested the hypothesis that a change in the temperature/rainfall pattern during the spring and summer would influence the weight gain pattern of the big brown bat.

MATERIALS AND METHODS

Nineteen maternal colonies in Delaware and Grant Counties, Indiana, were studied. Not all colonies were visited in each of the three years. Maternal colonies of the big brown bat are normally found in buildings. In some cases, the structure in which the bats were roosting was no longer present, or when visited in 1992, the bats were absent. Colonies that were located by Howell (1990) were revisited on or as close to the original date as possible. The authors assumed that bats

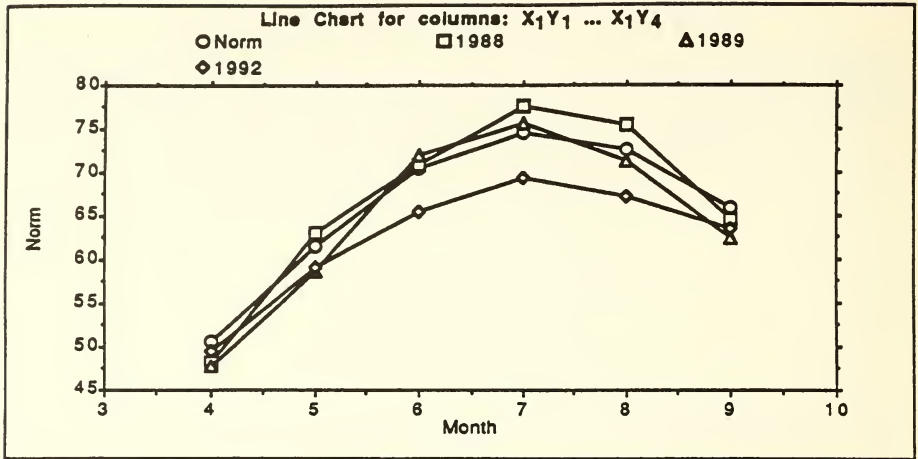


Figure 1. Mean monthly temperatures during the study period (May to September) during 1988, 1989, and 1992.

located in a similar geographic location would show the same pattern of weight gain.

To locate bat colonies, fliers that read "Bats Wanted" were posted in areas frequented by large numbers of people. In addition, public service radio interviews and announcements were used to let the public know bat colonies were being sought.

Suspected colonies were visited to verify identification. Bats were then captured with mist nets, butterfly nets, mechanic's bolt grabbers, or by hand. Observations began on 21 May 1992 and lasted until 22 September 1992. Captured bats were placed in a holding cage until release. Bats were weighed to the nearest 0.1 gram using an American Scientific Products digital scale and banded with a #2 flanged, individually numbered band (Gey Band and Tag Company).

All captured bats were examined for sex, reproductive condition (nursing or post lactating), tooth wear, and age.

Table 1. Number and average weight of bats caught by year.

Year	Number Caught	Average Weight (g)	Standard Deviation
Juvenile (total = 1069)			
1988	209	12.50	2.08
1989	219	13.68	2.55
1992	641	13.24	2.99
Adult Female (total = 1147)			
1988	311	18.21	2.20
1989	160	19.64	1.99
1992	676	19.07	1.86

Tooth wear was recorded as sharp, slightly worn, worn, and very worn. While tooth wear is not useful for indicating the specific age of individual bats due to wide individual variation (Mills, *et al.*, 1975), tooth wear was used to assign each bat to a broad age category. Age was recorded as either juvenile or adult. Bats were identified as juveniles (born that summer), if the epiphyseal cartilage had not been replaced by bone (Kunz and Anthony, 1982).

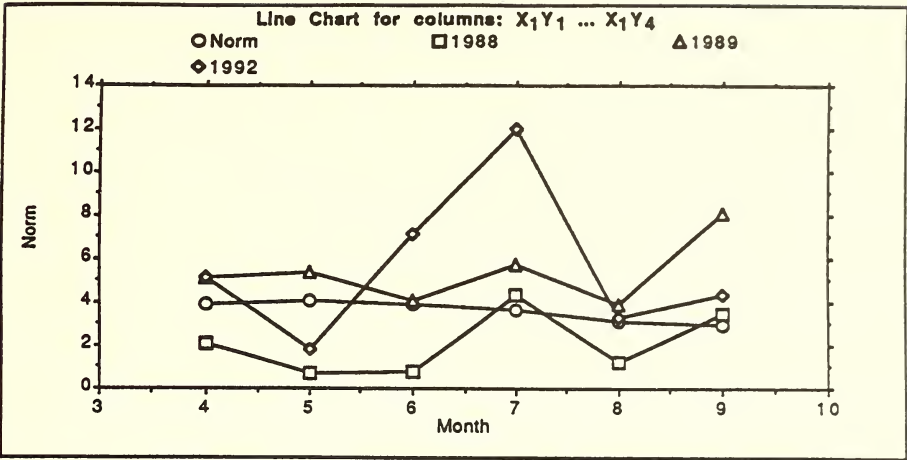


Figure 2. Monthly rainfall during the study period (May to September) during 1988, 1989, and 1992.

Weather information was obtained from the Ball State University Weather Station, Muncie, Indiana. The data were analyzed by multiple linear regression analysis using SPSS with the following variables: the dependent variable was weight on the day of capture; the independent variables were year (temperature/rainfall pattern), age, and day. Year and age were dummy coded. Day one was equal to 21 May.

RESULTS AND DISCUSSION

Mean monthly temperatures during the study period are shown in Figure 1. The mean monthly temperature is the sum of the daily average temperatures divided by the number of days in the month. The “Norm” is the average mean monthly temperature recorded over the 59 years for which records are available. In 1988, the warmest year during the study, temperatures averaged 1.8° F above normal. In 1989, the temperatures averaged 1.2° F below normal. In 1992, much of the summer had below normal temperatures. The average temperature for the season was 3.6° F below normal.

Figure 2 shows the total monthly rainfall for the same time period as

Table 2. Weather conditions and weight gain during each year of the study.

Year	Temperature	Rainfall	Juvenile Weight Gain	Adult Weight Gain
1988	Warm	Dry	Lowest	Lowest
1989	Middle	Wet	Highest	Highest
1992	Low	Very Wet	Middle	Middle

temperature (Figure 1). The “Norm” is the average total monthly rainfall for the 59 years for which records are available. As indicated, 1988 received

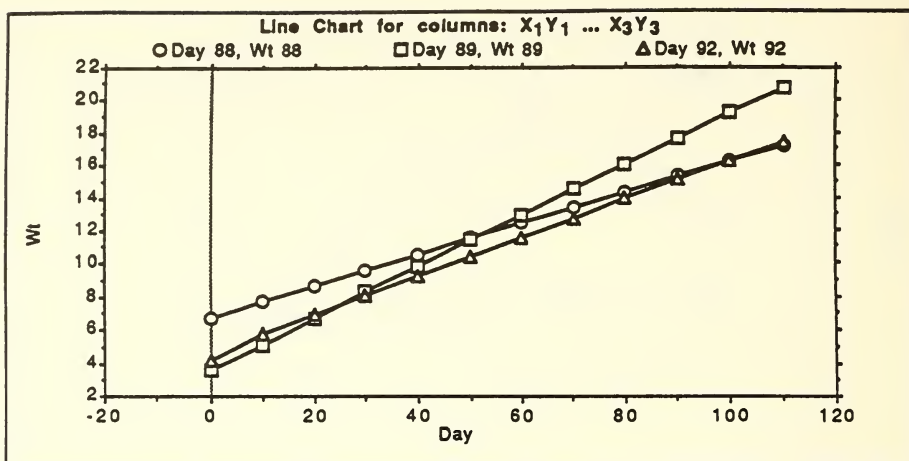


Figure 3. Weight gain pattern in juvenile males and females during 1988, 1989, and 1992.

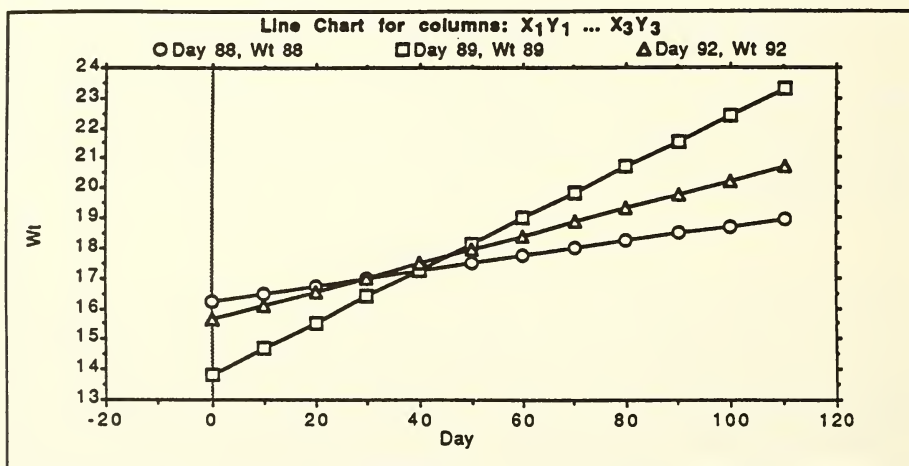


Figure 4. Weight gain pattern in adult females during 1988, 1989, and 1992.

below normal rainfall (8.9 inches below normal). Rainfall in 1989 was 10.6 inches above normal for the season and was evenly distributed throughout the summer. The summer of 1992 was the wettest of the three years, receiving 12.1 inches of rainfall more than normal. June and July had excessively heavy rains. June had 3.14 and July 8.32 inches of rain above normal.

Over the three years of study, a total of 2216 bats was captured (Table 1). Juveniles made up 48% of the total; 209 were caught in 1988, 219 in 1989, and 641 in 1992. The number of adult females captured was 311 in 1988, 160 in 1989, and 676 in 1992. Only adult females were recorded in this study due to the low number of adult males captured in maternal colonies (299 in three years). A small percentage of the bats (16%) were recaptured during the study. These bats were

included in the regression analysis after tests for normality found their effect to be insignificant.

To analyze the difference in the weight gain pattern between seasons, multiple linear regression analysis was used. Only data collected after day 40 (29 June) were used to compensate for the weight gain experienced by adult females prior to giving birth. The overall regression was significant ($F = 25.2$, $P < 0.00005$) and had an R^2 of 0.75. The R^2 s increase for year ($F = 64.6$, $P < 0.00005$), age ($F = 3582.3$, $P < 0.0005$), and their interactions with day (year, $F = 36.9$, $P < 0.00005$; age, $F = 25.2$, $P < 0.00005$) were significant. Therefore, individual equations for each age class by year were developed. Then, these six equations were used to calculate the difference in the weight gain pattern over time for juveniles and adult females in all three years (Figures 3 and 4).

In 1988, the year with dry weather and the warmest temperatures, juvenile bats had the slowest weight gain over time (Figure 3). During 1989, with wet conditions but normal temperature, juvenile bats had the fastest weight gain. In 1992, weight gain was slightly greater than in 1988. Rainfall was above normal in 1992, but temperatures were lower than normal (Figures 1 and 2).

Adult females had the slowest weight gain in 1988 (Figure 4). In 1989, the adult female bats started with the lowest weights but showed the fastest weight gain over the season. Their low starting weight was probably due to the low weight of the bats entering hibernation in 1988. In 1992, weight gain was just slightly faster than in 1988.

CONCLUSIONS

Rainfall and temperature both appear to be important factors affecting weight gain in the big brown bat (Table 2). The lowest rate of weight gain in both adult females and juveniles was associated with a year (1988) of very low rainfall and near normal temperatures. Above normal rainfall coupled with temperatures slightly below normal seemed to have a positive effect on weight gain in 1989 (Howell, 1990). The climate may have favored larger insect populations (Lack and Lack, 1951). However, rainfall that is far above normal, or excessively heavy at night (the time when foraging occurs), appears to have a slight negative effect, as seen in 1992. If a slower weight gain is related to excessive rainfall at night, the slowdown in weight gain could result from decreased insect activity, decreased foraging proficiency, or both (Church, 1957; Stebbings, 1968).

Below normal temperature, as seen in 1992, also seems to have a negative effect on weight gain. Perhaps bats are inefficient thermoregulators, and if energy is expended to warm themselves in the daytime roosts, growth is slowed. Colder nighttime temperatures during foraging could have a similar effect (Kunz, 1973; Racey, 1969). While weight gain appears to be associated with temperature and rainfall, these factors may not be the direct cause. More research on how weather conditions affect insect populations and bat thermoregulation is needed.

ACKNOWLEDGMENTS

The authors would like to thank the following people for their contributions: Ralph Kirkpatrick, William Rogers, Christi Alexander, Tom Gordy, Darrin

Hoggett, Jeff Laborda, and the Department of Biology, Ball State University. A special thanks to all of the people who allowed us to come into their homes and catch bats.

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INDIANA ACADEMY OF SCIENCE

COUNCIL MINUTES

NOVEMBER 4, 1993

Call to Order

The meeting was called to order by President Duvall Jones at 3:50 pm in room 320 of the Stewart Center at Purdue University, West Lafayette.

The following Council Members were in attendance: Bennett, Boener, Burden, Chesak, Daniell, Dolph, Frazier, Garber, Haddock, Hicks, Jensen, Johnson, Jones, Kritsky, Lovell, McBurney, McKnight, Melhorn, Mueller, Munsee, Parker, Riemenschneider, Rothrock, Schmelz, Warden, Warnes, and Webster. Also in attendance was W. Hasenmueller.

Approval of the Minutes

The Minutes of the previous meeting held on 23 April 1993 were accepted after minor typographical errors were corrected.

President's Report (Jones)

President Duvall Jones spoke briefly in general terms about the need to strengthen the Academy.

Treasurer's Report (Frazier)

Ed Frazier presented a short summary of our current financial status:

	Beginning Balance 1/1/93	Revenues YTD	Expenses YTD	Balance on Hand 9/30/93
Operating Fund	\$19,867.89	\$24,701.34	\$15,976.64	\$28,592.59
Total Restricted Funds	\$37,116.18	\$48,919.24	\$48,067.95	\$37,967.47
Total Funds	\$56,984.07	\$73,620.58	\$64,044.59	\$66,560.06

Ed mentioned that we may have a deficit, but he did not think that it would be in the \$12,000.00 range as was previously projected.

A motion was made and seconded to receive the report. The motion passed.

Executive Director's Report (Melhorn)

Bill Melhorn commented briefly on his progress in putting together the *Operations' Handbook*.

Editor's Report (Dolph)

Gary Dolph stated that Volume 102(1-2) was being bound by Haywood Printing at this time and that our copies should be delivered to the State Library very soon. Volume 102(3-4) has 9 edited papers and 3 more are being revised at this time. Currently, no backlog exists. Volume 98 is still at IU Printing Services. A printer malfunctioned, causing even further delay.

Report of the Director of Public Relations (Kritsky)

Gene Kritsky stated that the next issue of the *Newsletter* will be out December 1.

Old Business**Report of the *Ad Hoc* Personnel Committee (Chesak)**

David Chesak presented several recommendations to the Council for consideration:

1. A motion was made and seconded that no officeholder or chairperson should receive direct remuneration for services rendered to the Academy. Budgeted funds shall be spent only for goods and services needed to facilitate the work of the respective positions. After considerable discussion, a substitute motion (amendment) was made and seconded: Services rendered shall pass through normal budgetary procedures; authority for payment may be delegated to the President and/or the Executive Director by the Executive Committee as necessary. The substitute motion was approved. The original motion was defeated.
2. A motion was made and seconded to abolish the position of Executive Director. The duties of that office were to be redefined and assumed by a Corresponding Secretary. During discussion, it was pointed out that the Council approved the establishment of the Executive Director's position 5 years ago by a vote of 22 to 1. It was also reiterated that the position was part-time and not full-time as some misinformed Council Members were led to believe. Bill Lovell read the list of specific duties from the *Operations' Handbook*. The motion was defeated on a voice vote and a hand vote of 23 to 3.
3. A concern came up relative to dues collection and tabulation. A motion was made and seconded to have dues sent to our permanent mailing address at the State Library (in care of Holly Oster), and she should then forward the dues to the Treasurer for crediting and tabulation. The motion was approved.
4. The final motion made and seconded was that funds are to be allocated to Section Chairs to facilitate the administration of their tasks. The amount is not fixed but is to be based on need and the judgment of the Budget Committee. During discussion of this motion, it was pointed out that the Academy has already made some provisions in this area under Article IV, Sectional Organization, Sec. 4: "Expenses incurred by a Section shall in no way become a financial obligation of The Academy

except as authorized in the annual budget of The Academy." The motion was defeated.

Operations' Handbook (Melhorn)

Bill Melhorn presented a short summary of his progress in preparing the *Operations' Handbook*.

Reports of Elected Standing Committees

Research Grants Committee (Hicks)

David Hicks summarized a self-study recently completed by this Committee that showed that for the 1991-1993 period, 79% of the funded proposals came from Biology, 9% came from Physics, and 9-10% came from the remaining Sections. Is the bias due to small grant size (about \$900.00) which discourages those from academic areas where grant needs might be much greater or is this not a true cause and effect relationship?

The Committee's central concern was this: How can the Committee maximize the monetary benefits that are available to it? The monetary limit per grant is \$2,500.00, a figure which was set by Council vote some time ago. About \$37,000.00 is budgeted annually for disbursement by this Committee.

Additional comments and questions included: Can the program be made more well known in the Academy? We need more corporate sponsors to be able to increase funding. Can the Committee be given more authority (to change maximum funding limits, etc.)? Some concern was also expressed about increasing the funding for research.

Should we perpetuate the "seed money" concept or should we award fewer grants that are larger? After discussion subsided, President Jones recommitted the report to the Committee with the request that they re-evaluate the entire program with special attention to allocation and selection and report back to the Council no later than the Fall Meeting.

A summary of the grants given to college and university researchers was then presented. In the spring of 1993, 29 proposals were received. Of these, 23 grants were approved for funding at a total of \$20,400.00. In the fall of 1993, 15 proposals were received. Of these, 13 were approved for funding at a total of \$14,715.00.

A number of grants were also made to high school researchers. In the fall of 1992, 22 proposals were received. Of these, 17 were approved for funding at a total of \$2,000.00. In the fall of 1993, 26 proposals were received. As of this report, all the Committee Members had not returned their reviews.

Report of the Bonding Committee (Hammond)

We are now entering the third year of a three-year policy with Gregory and Appel Insurance of Indianapolis. Our coverage was increased to \$80,000.00 at the beginning of this three year policy period. As this bonding amount is still in line with the maximum amount of money on hand at any one time, following discussion with Edward Frazier, Treasurer, I recommend that we maintain the

current bonding level as adequate coverage for the Academy. The amount of money requested for the present year (\$188.00) represents the amount of the premium for the bonding coverage. This amount has been paid, and our policy is in effect for the 1993-1994 policy year.

Reports of Appointed Standing Committees

Amendments Committee (Zimmerman)

Jerry Zimmerman summarized the discussions of this Committee concerning the overall governance, administration, and function of the Academy:

1. There seems to be a lack of common understanding among members and officers as to the goals of the Academy.
2. The Academy seems to be losing its sense of historical context and precedent.
3. There is a lack of common understanding and agreement as to the manner in which the Academy conducts its affairs.

The recommendations of the Committee were:

1. Key policy documents of the Academy (particularly the Constitution and Bylaws) should be re-evaluated and, where necessary, modified or even created.
2. The roles and scope of authority of the various governing bodies must be better defined. Lines of authority must be clear and well defined.
3. Formal leadership development and member education are highly recommended. Member education and officer training should be part of every Spring and Fall Meeting.
4. Agendas must be realistic and appropriate to the work that needs to be accomplished.
5. A commitment to majority rule and a spirit of mutual cooperation are an absolute necessity.

Biological Survey Committee (Rothrock)

Paul Rothrock read a resolution prepared by this Committee entitled "A Resolution Regarding the Control and Use of Exotic Species of Plants and Animals." The full text of this very significant resolution appears as an addendum. A motion was made and seconded to adopt the resolution and to place it on the Agenda of the General Business Meeting. George Parker had some friendly wording changes, and the motion was approved subject to Rothrock and Parker getting together to improve the wording.

Emeritus Member Selection Committee (Hopp)

The following members were presented to the Council as eligible for consideration as Emeritus Members:

James B. Cope	K.W. Nightenhelser
Arthur L. Eiser	John F. Schafer
Mary F. Ericksen	Charles E. Smith
Virgil R. Knapp	Frank J. Zeller

A motion was made and seconded to accept the above as Emeritus Members and to forward their names to the general membership for their approval. The motion was approved.

Fellows Committee (Schmelz)

The following members were presented to the Council as being eligible for nomination to the status of Fellow:

David L. Daniell
A.J.C.L. Hogarth

Stephen A. Perrill

A motion was made and seconded to approve the above nominations and to forward their names to the general membership for approval. The motion was accepted.

Library Committee (Oster)

The following is a brief summary of Holly Oster's report.

During fiscal year 1993, sixteen new exchange titles were added. Two exchanges were added, and one was canceled. In the period October 1992 to October 1993, 618 interlibrary loan requests were processed. *The Proceedings of the Indiana Academy of Science* were distributed. Also, copies of *Science Education at the Crossroads* were distributed to exchange libraries.

The Library Committee has agreed with the Publications Committee that exchange copies of the Academy's new series of special publications should only be sent to those exchange partners which are sending us comparable publications. A preliminary list of those institutions has been prepared.

In response to an inquiry from the Russian Academy of Sciences' Library in St. Petersburg (formerly Leningrad), the Committee has agreed to supply a backset of *Proceedings* Volumes 1-30 to replace those lost in a major fire several years ago.

Due to staffing shortages, no additional periodical volumes were prepared for binding.

By January 1994, the Indiana State Library online catalog, which includes portions of the J.S. Wright Memorial Library catalog, will be available on the Internet and in State Agencies via the State's mainframe backbone.

Local Arrangements (Parker)

This evening's dinner will be at Bruno's.

Membership Committee/Membership Secretary (Mueller and Jones)

As of 4 November 1993, there were 1,052 memberships for 1993. Two hundred nineteen (219) persons resigned or did not pay dues in 1993; 94 new members joined the Academy in 1993 (as of this date).

Nominations and Elections Committee (Webster)

President-Elect	Gene Kritsky
Treasurer	Ed Frazier
Academy Foundation	Frank Guthrie
Research Grants	Paul MacMillan

The report was received.

Program and Invitations Committee (Warnes)

The budget for the meetings in South Bend in 1994 will need to be revised due to an anticipated increase in the number of Junior Academy Members attending. Their budget can be finalized at the December Budget Meeting.

The work of the Program and Invitations Committee as well as the Local Arrangements Committee would be facilitated, if a budgetary timetable were prepared by the Budget Committee.

Plans are well underway for the 1994 IAS meetings. A tentative budget has been proposed in consultation with the IUSB planners. Special thanks are extended to Larry Garber for his efforts to help the Academy control costs. The Local Arrangements Committee is chaired by Victor Riemenschneider.

The 1995 meetings will be hosted by IUPUI. Local Arrangements Committee co-chairs are Laura Jensi and Doug Lees of the Biology faculty. Others serving on the Local Arrangements Committee are Gordon Fricke (Chemistry) and Nassor Paydar (Mechanical Engineering). Information has been forwarded to the co-chairs on their responsibilities (including budgetary). If their budget request is to be made prior to the winter (as was done this year), the Committee needs to be quicker in sending out tentative guidelines and corrected timetables.

Selection of a host institution for the 1996 IAS meeting is underway.

Publications Committee (McKnight)

A motion was made and seconded to institute page charges for publication in the *Proceedings* and to not require authors to be members. These changes would not go into effect until after their approval and until after the rates are published in the *Proceedings*. The motion was approved.

A proposal was made that dues for Emeritus Members should be equal to those for Student Members. A motion was made and seconded to refer this matter to the Membership Committee. The motion was approved.

Resolutions Committee (Haddock for Morse)

A resolution was read thanking Purdue University for the use of its facilities and George Parker and his Committee in particular for hosting the Fall 1993 Meeting. A motion was made and seconded to the above and was approved.

Youth Activities Committee (Rhodes)

Twenty-five schools attended the Fall Meeting held at Ball State University in Muncie on 6 November 1992. The 46th Indiana Academy of Science Talent

Search was held on 5-6 March 1993 at Ball State University and was attended by 16 students representing 14 high schools.

The Committee has taken a much needed step toward improving communications with secondary school science teachers this year. That step was the publication and mailing of a four page Indiana Junior Academy of Science newsletter, entitled *Scientific Notations*, to high school science teachers and their students. The newsletter's purpose was to inform them of the Academy's youth programs and to encourage their participation. Plans are to produce two newsletters each year, one in September and another in February.

The Indiana Science Olympiad was held on 3 April 1993 at Indiana University, Bloomington, with 52 schools attending. Eight scholarships totaling \$6,000.00 were awarded. The scholarships are to be used at Indiana colleges and universities.

The Chairperson wrote a policy statement for the Academy's *Operations' Handbook*.

Report of the Academy's Representative to the Indiana Natural Resources Commission (Schmelz)

Damian Schmelz chaired the Brown County State Park Deer Study Committee for the Director of the Department of Natural Resources. The report was completed and forwarded to the Director in February 1993. At its regular September meeting, the NRC unanimously approved the essential features of the report, and a one day "hunt" was scheduled for December 1993 to reduce the deer herd significantly, provided that the Attorney General's Office resolves a counteraction filed by an animal rights group.

Awards

Discussion of an Outstanding Service Award and an IAS Distinguished Scholar Award was tabled.

Report of the High School Teacher Fellowship Committee (Ober)

The Committee received one research proposal for the 1992-1993 year, and it was not awarded because the request was for equipment rather than for salary as specified in the guidelines. The Committee recommends that grant support be used for both salary and/or equipment.

Report of the Natural Areas Committee (Riemenschneider)

The Natural Areas Committee initiated its permanent plot registry program this spring. The Committee sent a cover letter and a form to all ecologists in Indiana, requesting information on permanently marked plots. The Committee has received 20 completed forms as of this date. A draft copy of Committee's goals and responsibilities was sent to the members for discussion at the Fall Meeting.

Report of the Science Education Advisory Committee (Ruesink)

Here is a brief statement of the goals of the Science Education Advisory Committee (SEAC) of the IAS:

1. To become active again and to meet several times during the course of the year.
2. To assess what Committee Members believe to be the biggest challenges facing science educators in Indiana.
3. To determine how the SEAC and the IAS might have positive impacts on science education in the State of Indiana.
4. To promote such impacts.

Report of the Speaker of the Year Selection Committee (Daniell)

Dr. David Beranek, President of the Indiana Environmental Institute, was selected as Speaker of the Year. His presentation at the Fall Meeting of the IAS at Purdue University was entitled "Environmental Priorities in the United States: How Did We Get Here, and Where Are We Going?"

During the selection of a Speaker of the Year, the Committee found that none of the suggested speakers were members of the Academy. This year, the selected speaker was willing to renew his membership. A proposed change in the Bylaws will make the selection process easier. The Committee would appreciate the names of scientists who would be appropriate speakers at future Fall Meetings.

Report of the Science and Society Committee (Bennett)

A suggested long-range plan for the Committee has been developed. The names of speakers are being placed in a computer file. A report on wetlands management appeared in the June *Newsletter* along with a request for volunteers to work on a position paper on the clearing of drainage ditches. The Committee would appreciate the names of scientists who would be appropriate speakers at future Fall Meetings.

Report of the Undergraduate Programs Committee (Perrill)

This Committee is in the process of brainstorming any and all ideas that might facilitate undergraduate research activities throughout the State. The initial thought was to hold some kind of separate activity at the Fall Meeting of the Academy such as a separate session for undergraduate presentations or a luncheon for undergraduate researchers and their faculty mentors. Following conversations with several faculty members from a number of different institutions throughout the State, the Committee decided that the Fall Meetings are already too packed with activities to add yet another separate event.

Events that encourage undergraduate research that are already in place include the Fall Meeting of the Academy and the Butler Undergraduate Research Conference (held in April and also sponsored by the Academy). These two conferences offer excellent opportunities for students to present the results of their research efforts. This Committee will continue to consider other avenues to encourage more undergraduate research activity throughout the State.

Report of the Academy Representative to the AAAS (Kritsky)

The NAAS Workshop represented the first effort by this group to provide some interaction between the State Academies and to help them gain from each other's experiences. One item of interest was the 35% increase in membership in the Ohio Academy of Science that resulted from designating contact people at each college and university in that State, who would act as recruiters. The Ohio Academy of Science also has a calendar tracking program that monitors when dues notices and follow-up notices are sent to help maximize retention and recruitment.

Other special activities by the State Academies included:

1. The New Mexico Academy of Science is involved with the New Mexico Museum of Natural History. Their current activities include building a science museum.
2. Several academies have exhibits at their State Fairs.
3. Ohio has an Industrial Council to encourage corporate contacts.
4. The Indiana Academy of Sciences' publication record for books, the *Newsletter*, and especially the *Proceedings* was clearly the envy of many academies.

Section Y meetings resulted in a major change in decision-making relative to symposia selections. Efforts have been underway for a year to reduce the control of the Washington staff in dictating symposia selection.

Adjournment

The Council Meeting was adjourned at 6:15 pm.

Respectfully submitted,

Jim Haddock
Secretary

ADDENDUM

**THE BIOLOGICAL SURVEY COMMITTEE'S RESOLUTION
A RESOLUTION REGARDING THE CONTROL
AND USE OF EXOTIC SPECIES OF PLANTS AND ANIMALS**

Whereas

As a community of scientists, we have long observed an alarming decline in the extent of some native Indiana flora and fauna and in the natural biodiversity of the State;

This decline has been worsened by the introduction of non-native species (herein referred to as exotic species) by accidental or intentional means;

The serious economic, biological, and public health consequences of some exotic species have recently received an extensive review through the Exotic Species Conference and published proceedings sponsored by the Indiana Academy of Science;

Some State Agencies practice management policies which promote the use of exotic species in conservation plantings and recreation even when suitable native species are available;

Adjacent States, most notably Illinois, have developed programs designed to control invasive exotics and promote the use of planting stock raised from native seed sources;

The public requires further information about the effects exotic species have on natural ecosystems and public health and their potential economic impacts.

Therefore

The Indiana Academy of Science and its Biological Survey Committee support the following exotic species policy for the State of Indiana:

1. When appropriate, to reduce and stop the use of exotic species of plants and animals for conservation, landscape, and recreational purposes;
2. To promote the use of native species for conservation, landscape, and recreational purposes;
3. To encourage the education and training of citizens in the biological, health, and economic risks of some exotic species and the benefits of the utilization of native species;
4. To seek policy which excludes the sale, use, or transfer of the most invasive and deleterious exotic species;
5. To encourage management strategies for the control and eradication of current problem species;
6. To seek the creation of Exotic Species Coordinator positions in four existing State Agencies. These individuals will be charged with implementing a successful exotic species control program in the following areas:
 - a. Insects by the Division of Entomology;
 - b. Non-insect animals by the Division of Fish and Wildlife;
 - c. Plants by the Division of Nature Preserves; and
 - d. Fungi and pathogens by the Division of Forestry.

INDIANA ACADEMY OF SCIENCE EXECUTIVE COMMITTEE MINUTES NOVEMBER 4, 1993

Call to Order

The meeting was called to order by President Duvall Jones at 1:20 pm in room 120 of the Stewart Center at Purdue University, West Lafayette.

The following members of the Executive Committee were in attendance: Dolph, Frazier, Haddock, Jones, Kritsky, Lovell, Melhorn, and Mueller. There were approximately six additional Academy members in attendance.

Approval of the Minutes

The Minutes of the previous meeting held on 11 September 1993 were accepted after minor errors were corrected.

Approval of Agenda

Minor modifications were made in the agenda, which was then approved.

Treasurer's Report (Frazier)

The following is a short summary of the Treasurer's Report:

	Beginning Balance 1/1/93	Revenues YTD	Expenses YTD	Balance on Hand 9/30/93
Operating Fund	\$19,867.89	\$24,701.34	\$15,976.64	\$28,592.59
Total Restricted Funds	\$37,116.18	\$48,919.24	\$48,067.95	\$37,967.47
Total Funds	\$56,984.07	\$73,620.58	\$64,044.59	\$66,560.06

Ed Frazier mentioned that we may have a deficit, but he does not think that it will be in the \$12,000.00 range as was previously projected.

Foundation Report (Melhorn for Guthrie)

Frank Guthrie, Chair, is currently on sabbatical on the East Coast, and Bill Melhorn summarized his report by saying that our assets are up (bond prices, for example, increase as yields fall) but that our income is down (due to the lower yields that we receive on new bonds purchased after the old ones have matured).

Old Business

Report of the Nominations and Elections Committee (Webster)

President-Elect	Gene Kritsky
Treasurer	Ed Frazier
Academy Foundation	Frank Guthrie
Research Grants	Paul MacMillan

The Committee extends its appreciation to all of the members that stood for election.

Report of the Search Committee for the Executive Director (Mueller)

The Committee received two applications by the 1 October 1993 deadline. The two candidates were Bill Lovell and Bill Melhorn.

Report of the Personnel Committee (Chesak)

A summary of the recommendations from their meeting of 13 March 1993 was distributed. The report was received. There was moderate discussion, but no action was taken on any of the three proposals. For information purposes, the proposals are listed below:

1. No officeholder or chairperson should receive direct remuneration for services rendered to the Academy. Budgeted funds shall be spent only for goods and services needed to facilitate the work of respective positions.
2. The position of Executive Director should be abolished, and the duties of that office should be redefined and assumed by a Corresponding Secretary.
3. Funds are to be allocated to Section Chairs to facilitate the administration of their tasks. The amount is not fixed but is to be based on need and the judgment of the Budget Committee.

Selection of the Executive Director (Mueller)

The Executive Committee moved to Executive Session; non-members and the two candidates exited the room. The strengths and goals of each candidate were assessed confidentially, and both candidates were briefly interviewed. Voting then took place, and Bill Lovell was declared the winner.

The entire Executive Committee and guests then reconvened, and the result of the voting was declared — Bill Lovell will begin his appointment as the new Executive Director on 1 January 1994. The Committee also wishes to thank Bill Melhorn for his efforts and accomplishments during his tenure as Executive Director.

***Operation's Handbook: Duties of the Executive Director* (Melhorn)**

Bill Melhorn presented a short summary of his progress in preparing the *Operation's Handbook*. A motion was made and seconded to approve Sect. 6.2.3 dealing with the duties of the Executive Director. Considerable debate occurred relative to the Executive Director's role in handling the responsibility of tracking

membership applications and the collection of dues. An amendment to assign this to a Membership Secretary (still an unofficial, appointed position) died for lack of a second. The original motion was then approved.

A motion was made and seconded to postpone discussion of the following four items:

- Establishment of an Environmental Engineering Section
- Guiding Resolution for Membership Growth
- Guiding Resolution for Corporate Growth
- Resolution for Establishment of a Past President's Fund

The motion was approved.

Publications Committee Report (McKnight)

The Publications Committee has recommended that Gary Dolph be reappointed as Editor of the *Proceedings* and that the annual stipend be increased from \$2,000.00 to \$4,000.00. A motion was made and seconded to appoint Gary Dolph as Editor for another three-year term at an annual stipend of \$4,000.00. The motion was approved.

The Chair of the Public Relations Committee (Gene Kritsky) tendered his resignation effective January 1994 so that he can begin his responsibilities as President-Elect. A motion was made and seconded to accept Gene's resignation, to advertise the opening in the upcoming *Newsletter* and to forward names of candidates for the position from the Executive Committee to the Publications Committee for the latter's review and comment. The motion was approved.

The Youth Activities Committee recently published a Junior Academy newsletter, and the Publications Committee has expressed some friendly concern relative to the format (not content) of this publication. A motion was made and seconded to approve a "one-time look" at the Junior Academy's newsletter by the Publications Committee in concert with the Youth Activities Committee in order to present suggestions for format improvement. The meeting should occur before the Budget Committee Meeting in early December. The motion was approved.

The final item of this Committee was a request that the Academy pay the final publication bill to IU Press for the *Orchids of Indiana*. A motion was made and seconded to grant the Treasurer authority to pay a bill of \$45,822.61 (as opposed to \$42,000.00) which is now due for the *Orchids* and that we acknowledge a change from a 50:50 split on future profits with IU Press to a 60:40 split in favor of the Academy. The motion was approved.

Resolution on Exotic Species (Rothrock)

Paul Rothrock read a resolution by the Biological Survey Committee dealing with exotic species (see pp. 107-108). The document was accepted. A motion was made and seconded to recommend the resolution to the Council for action. The motion was approved.

New Business**Budget Committee Meeting for 1994**

President-Elect Wayne Mueller set the meeting for 9:30 am, Saturday, 4 December 1993, and it is to be held at Speedway High School in Indianapolis. In addition, there may be an Executive Committee meeting after the 1994 Budget is settled.

Adjournment

The meeting was adjourned at approximately 3:30 pm.

Respectfully submitted,

Jim Haddock, Secretary

INDIANA ACADEMY OF SCIENCE EXECUTIVE COMMITTEE MINUTES FEBRUARY 5, 1994

Call to Order

The meeting was called to order by President Wayne Mueller at 10:00 am at Speedway High School, Speedway, Indiana.

The following members of the Executive Committee were in attendance: Dolph, Frazier, Haddock, Jones, Kritsky, Lovell, and Mueller. Other Academy members in attendance were Bill McKnight and Holly Oster.

Approval of the Minutes

The Minutes of the previous meeting held on 4 November 1993 were accepted, after errors were corrected.

Approval of Agenda

Minor modifications were made to the Agenda. which was then approved.

Publications Committee Report (McKnight)

Bill McKnight briefly reviewed the proposed Memorandum of Agreement with Purdue University Press, which basically is a general sales agreement. Net receipts will be split 60:40. A motion was made and seconded to approve the Agreement. The motion was approved.

A motion was made and seconded to approve the Memorandum of Agreement with Purdue University Press for the Charlie Deam book. The motion was approved.

Executive Director's Report (Lovell)**Housekeeping Items**

1. The membership file is in the process of being transferred to the Executive Director's office.
2. A gift of \$1,000.00 was made to the Science Talent Search by PSI (Public Service Indiana) Energy. A motion was made and seconded to make PSI a Corporate Member as a token of our gratitude. The motion was approved.
3. Bill Lovell will be helping President Wayne Mueller with the printing of the *IAS 1994 Yearbook*. About 200 copies will be printed.
4. The Academy needs to conclude a contract with the Executive Director as soon as possible.

Short Term Recommendations

1. Emeritus Members. Some consideration should be given to charging Emeritus Members for the *Proceedings*, if they elect to receive them. Also, Emeritus Members are not known to have the vote in any organization. There should be some thought given to changing the IAS position on this in the future. It would only be fair to have present Emeritus Members "grandfathered."
2. Membership Upgrade. A membership upgrade campaign is needed to increase the financial commitment of members to the Academy. The Academy has been at least indirectly associated with the career advancements of many Academy members, and this should be pointed out through "testimonials" by fellow Academy members either in the *Newsletter* and/or associated with a membership drive.
3. Code of Ethics. The Academy should give serious thought to a written code of ethics that might help us attain and adhere to a higher standard of conduct vis-a-vis our colleagues while engaging in Academy business. President Wayne Mueller will organize a subcommittee to study this issue.
4. Establishment of a Past Presidents Fund. Past Presidents would be solicited for a contribution that could be used for special projects.

Long Term Recommendations

1. Consideration of a name change for the IAS to the "Indiana Academy of Science and Engineering."

Letter to Jones (Mueller)

President Wayne Mueller read a prepared letter written to Duvall Jones in which he expressed numerous concerns about accusations expressed by Duvall in a previous letter addressed to Wayne, sent to the Council, and written on IAS letterhead. The concern expressed by President Mueller was that the accusations

(relative to leadership decisions in the Academy over the past few years) were unsubstantiated in Duvall Jones' letter.

After a short and thoughtful discussion, a motion was made and seconded to ask Duvall Jones to provide names of any Academy members, who were not treated with utmost respect while discussing their ideas in any Executive, Council, or General Business Meeting held at any time in the past. The motion passed.

Treasurer's Report (Frazier)

The following is a short summary of the Treasurer's Report.

The balance on hand as of 31 December 1993 was approximately \$8,000.00 less than for a comparable date in 1992 (\$11,999.73 in contrast to \$19,867.89). About \$7,000.00 of the shortfall was due to the higher costs of the Spring and Fall Meetings held in 1993 at Purdue University.

1. Under "Balance on Hand," \$2,583.17 was removed from the Exotic Species Fund (since that project is finished) and placed under its parent, the Publication Fund.
2. Academy Publication Sales. A total of \$13,451.71 plus another \$2,816.00 from the sale of outside publications was realized for the year. Thanks to Bill McKnight and the Publications Committee for a job well done!

Updated financial report:

	Beginning Balance 1/2/93	Revenues YTD	Expenses YTD	Balance on Hand 12/31/93
Operating Fund	\$19,867.89	\$35,627.91	\$43,496.07	\$11,999.73
Deferred 1994		\$2,500.00		\$2,500.00
Total Restricted Funds	\$37,116.18	\$124,938.50	\$121,931.74	\$40,122.94
Total Funds	\$56,984.07	\$163,066.41	\$165,427.81	\$54,622.67

Editor's Report (Dolph)

Gary Dolph reported that Volume 102(3-4) should be out in about two months. The work is being performed by Haywood Printing Company. Gary will be starting work on the Index for Volume 98 in a couple of weeks.

The Editor reviewed with the Executive Committee the unevenness of Sections relative to the receipt of manuscripts suitable for publication. Anthropology, Entomology, Geology, Cell Physiology, Microbiology, and Physics/Astronomy were identified as Sections that were particularly lean on manuscripts. The Academy Secretary was requested to include an encouraging note to the Chairs of the above Sections in the annual "Letter to Section Chairs" in hopes of resurrecting some interest in publishing in the *Proceedings*.

Old Business

Plans for the 1994 meetings at IU South Bend and the 1995 meetings at IUPUI are progressing well.

The members of the Executive Committee will be reviewing portions of the *Operations' Handbook* a section at a time as President Wayne Mueller sends them in the mail. The goal is to have a considerable portion reviewed collectively and "passed" at the Spring Meeting at IU South Bend.

Membership Report (Jones)

As of 31 December 1993, there were 1193 members in good standing including:

120	Associate Members	2	Institutional Members
34	Club Members	11	Life Members
3	Corporate Members	630	Regular Members
100	Emeritus Members	236	Student Members
3	Honorary Members	54	Sustaining Members

Duvall Jones recommended that a membership form be included in the Program and Abstracts booklet.

Search for a Public Relations Director

A replacement for Gene Kritsky, who is currently serving as President-Elect, is still needed.

Review of the Constitution

President Wayne Mueller has asked the Amendments Committee to review and make recommendations for substantive changes in the Constitution. Bill Melhorn is serving as Chair of the Amendments Committee.

Newsletter

The next issue of the *Newsletter* will be out around 15 March.

Pre-Publication Discount

A motion was made and seconded to give Academy members a pre-publication discount on the forthcoming book, *Plants of the Chicago Region*. The motion was approved.

AAAS

Gene Kritsky will be giving a report on publications at the next AAAS Meeting.

Next Meeting

The next meeting of the Executive Committee will not be held until the Spring Meeting of the Academy on 29 April 1994 at South Bend, unless one is needed to keep up with current business.

Adjournment

A motion was made and seconded to adjourn at approximately 12:10 pm. The motion was approved.

Respectfully submitted,

Jim Haddock, Secretary

INDIANA ACADEMY OF SCIENCE EXECUTIVE COMMITTEE MINUTES APRIL 29, 1994

Call to Order

The meeting was called to order by President Mueller at 1:05 pm in a conference room in the Administration Building on the IU South Bend campus.

The following members of the Executive Committee were in attendance: Dolph, Frazier, Haddock, Jones, Kritsky, Lovell, and Mueller. Additional Academy members present included: Garber, McKnight, and Riemenschneider.

Approval of the Minutes

The Minutes of the previous meeting held on 5 February 1994 were accepted after minor errors were corrected.

Approval of the Agenda

Minor modifications were made to the Agenda, which was then approved.

Treasurer's Report (Frazier)

The following is a short summary of the Treasurer's Report:

Fund Accounts	Beginning Balance 1/2/94	Revenues YTD	Expenses YTD	Balance on Hand 3/31/94
Operating Fund	\$14,499.73	\$8,929.69	\$5,580.20	\$17,849.22
Total Restricted Funds	\$40,122.94	\$39,634.71	\$44,917.86	\$34,839.79
Total Funds	\$54,622.67	\$48,564.40	\$50,498.06	\$52,689.01
Funds on Deposit	Beginning Balance 1/2/94	Deposits	Withdrawals	Balance on Hand 3/31/94
Checking	\$2,522.30	\$60,596.14	\$48,253.97	\$14,864.47
Money Market	\$16,990.82	\$5,779.01	\$15,000.00	\$7,769.83
CD's	\$35,109.55	\$479.48	\$5,534.32	\$30,054.71

Ed Frazier finished his report by noting that the Academy is in good financial shape at this time.

Executive Director's Report (Lovell)

Bill Lovell's very complete report as of 29 April 1994 was subdivided into two sections — "Duties Performed" and "Initiatives Supported." The complete text of his report appears as the first item in the addenda (pp. 120-121).

Editor's Report (Dolph)

Gary Dolph stated that Volume 102(3-4) has been approved for publication. Volume 103(1-2) has 10 and 103(3-4) has 2 approved papers scheduled for publication. The Index for Volume 98 has been completed. Proofs of Volume 98 should be returned to Gary this week, and corrections will need to be made. The issue of page charges has not yet been resolved by the Publications Committee.

Report of the Amendments Committee (Melhorn)

This Committee has been charged with scrutinizing the Constitution and Bylaws for "redundancies, wordiness, and inconsistencies" and to report these as non-substantive changes. The Committee has a number of changes to report. A motion was made and seconded to accept the report on these changes. The motion was approved. The complete report on non-substantive changes is included as the second item in the addenda (pp. 121-124). It should be pointed out that these editorial changes in the Constitution and Bylaws may be made without submitting such changes to a vote of the Council or the membership of the Academy.

The Committee will be meeting over the summer to look at substantive changes which will require approval of the Council and the membership of the Academy at some future date. The Committee actively encourages input and advises that it be very specific and in written form.

Report of the Biological Survey Committee (Rothrock)

Paul Rothrock submitted 2 reports which are included in the addenda: "Establishment of an Indiana Biological Survey and Museum of Natural History" (pp. 124-126) and "Indiana Biological Survey (IBS) Implementation Strategy" (pp. 126-127). The basic concern is that Indiana is losing its natural history resources. The establishment of an Indiana Biological Survey (IBS) might be a way of turning the tide. A motion was made and seconded to accept the reports. The motion was approved. A suggestion was made to dovetail this action with the goals of the Science and Society Committee to form a joint Academy project. This is a policy issue that will have to be brought up before the Council.

Report of the Local Arrangements Committee (Riemenschneider)

Victor Riemenschneider announced that the Fall Meeting will be held in one building. He will be contacting Section Chairs relative to their space and room needs.

Report of the Natural Areas Committee (Riemenschneider)

Victor Riemenschneider read a resolution prepared by this Committee supporting the population control of white-tailed deer in our State Parks. The complete text of the resolution appears as item 4 in the addenda (p. 127). The final paragraph reads, "Be it resolved that the Indiana Academy of Science requests the Governor of the State of Indiana to implement the recommendations of the Brown County State Park Deer Study Committee in State Parks showing significant impact of excessive deer browsing." A motion was made and seconded to accept the resolution. The motion was approved. This resolution will be forwarded to the Council because it is a policy issue.

Report of the Research Grants Committee (Frazier for Hicks)

In the spring round of competition, 35 requests for research funding were received by the Committee, and 29 of them were funded. The total amount expended was \$19,120.00 of the approximately \$41,000.00 that had been requested. There was \$37,000.00 budgeted for the year, which means that approximately 50% of the budgeted funds will be available for the fall competition.

Report of the Nominations and Elections Committee (Boener)

Charlotte Boener reviewed the highlights of her report which appears as item 5 in the addenda (p. 128). A motion was made and seconded to accept the report. The motion was approved. Part or all of the report will be published in an early Spring 1995 *Newsletter*

Report of the Publications Committee (McKnight)

The Academy is still looking for an Editor for the *Newsletter*.

A motion was made and seconded to have the Council take a close look at splitting the position of *Newsletter* Editor from that of Public Relations Director. The motion was approved.

Book sales have increased dramatically since the first of the year! The Academy is now starting to encounter major storage problems. Books are now being stored in the State Library, but Holly Oster needs the space for other publications. The Academy needs an amount of storage space equivalent to that in a one car garage. Bill McKnight will be attempting to resolve this issue before the Fall Meeting.

A motion was made and seconded to increase the publication budget for *Plants of the Chicago Region* from its original \$40,000 to \$48,000 so that the press run could be increased from 2,500 to approximately 5,000 copies. The motion was approved.

A motion was made and seconded to allow Bill McKnight to formulate a Memorandum of Agreement with the Morton Arboretum for publication of *Plants of the Chicago Region*. The motion was approved.

A motion was made and seconded to allow Bill McKnight to form a contract with Bookcrafters of Chelsea, Michigan, for printing *Plants of the Chicago Region*. The motion was approved.

A motion was made and seconded to transfer \$6,000.00 from the *Wetlands and Quiet Waters* project to the *Field Guide to the Freshwater Mussels of the Midwest* project. The former will not appear until 1995 because of publication delays. The motion was approved.

A motion was made and seconded to approve the expenditure of \$16,500.00 for Weimer Graphics to typeset the *Biological Pollution* manuscript. The motion was approved.

A motion was made and seconded to provide an additional stipend of \$1,000.00 to the Editor using the money coming from savings on the Deam text. The motion was approved.

Report of the Programs and Invitations Committee

No report.

AAAS Report (Kritsky)

The last annual meeting of the NAAS was held in February 1994 in San Francisco. A new publication sponsored by NAAS is *BASE*, a science and technology journal. A new format for the State Directories is being formulated, and the delegates approved a new Constitution.

Report of the Auditing Committee (Ricketts)

A motion was made and seconded to accept the Auditing Committee's report (p. 129) which stated that, "the financial records of the Indiana Academy of Science for fiscal year 1993 have been examined by the undersigned [Ricketts and Olsen] and appear to be a fair and accurate record of the financial condition of the Academy." The motion was approved.

Old Business

Past Presidents' Fund

Bill Lovell made a significant contribution to the fund to get it started off on the right foot. Thanks for your generosity Bill! Some thought will have to be given on how to use these funds as they grow and generate interest.

Code of Ethics

Gene Kritsky read a series of statements taken from a Code of Ethics for another organization. No action was taken. However, President Mueller referred the matter to the Council.

Special Service Award

A motion was made and seconded to name Wayne Mueller the first recipient of the Special Service Award. The motion was approved.

New Business

Donation of a Computer and Printer

A motion was made and seconded to contribute one aged MacPlus computer and printer to St. Joseph College. This equipment was used by Duvall Jones while he served as Membership Secretary. The motion was approved.

Announcements

Ben Moulton sends regrets for not being able to meet with us due to his wife's health problems.

Next Meeting

The next meeting will be in early July.

Adjournment

A motion was made to adjourn at approximately 3:00 pm. The motion was approved.

Respectfully submitted,

Jim Haddock, Secretary

ADDENDA

REPORT OF THE EXECUTIVE DIRECTOR 29 APRIL 1994

Duties performed

1. Transferred Membership Directory to a Purdue PC.
2. Mailed two dues billings (January and April).
3. Helped President Wayne Mueller appoint Committees.
4. Arranged for the printing and distribution of the *Yearbook*.
5. Prepared meeting agendas and requested presenters to attend.
6. Prepared material for the *Newsletter*.
7. Made corrections/additions to the Membership Directory.
8. Answered correspondence as needed.
9. Projected a positive attitude and optimism about the future of the Academy in all comments, conversations, and correspondence.

Initiatives Supported

1. Completed the first draft of the *Operations' Handbook*.
2. Supported the complete update of the Constitution and Bylaws.
3. Proposed changing the organization's name to the "Indiana Academy of Science and Engineering."
4. Supported instituting charges for the *Proceedings* for Emeritus Members.
5. Supported the re-examination of the voting privileges of Emeritus Members.
6. Initiated campaign "Membership Upgrade."

7. Initiated a youth movement in new leadership.
8. Supported the establishment of an Academy Code of Ethics.
9. Proposed the establishment of the Past Presidents' Fund.
10. Proposed the establishment of a Distinguished Service Award and an Accomplishment Award.
11. Built a spirit of esteem, loyalty, good will, cooperation, optimism, and collegiality in the Academy.
12. Expanded financial support for Research Grants, Publications, Youth Activities, the Junior Academy, and others.
13. Gave total support to the programs/initiatives of our outstanding incumbent Academy President for 1994.

Respectfully,

Bill Lovell

April 27, 1994

MEMORANDUM FROM THE AMENDMENTS COMMITTEE

From: Amendments Committee
Wilton N. Melhorn, Chair

Date: April 24, 1994

The current (April 1994) Academy *Newsletter* suggests, in an article by President Mueller (as I discussed earlier with him by telephone), that the Amendments Committee is charged with "ferreting out redundancies, wordiness, and inconsistencies" in the existing Constitution and Bylaws. The further understanding is, that once this cleanup is accomplished, that the Amendments Committee has an additional, major charge of very carefully going over this document with the object of devising and recommending any substantive changes which need to be brought before the Executive Committee and the Council for consideration, discussion, and approval.

Existing Bylaw Article XII, Sec. 3, empowers the Executive Committee, upon advice of the Parliamentarian (the Chair of the Amendments Committee), to make technical and non-substantive editorial changes in the Constitution and Bylaws without submitting such changes to a vote of the Council or the Academy membership. Inasmuch as the present governing document, since its adoption in 1985, has undergone amendments, as well as consistent repetition in print without editing, certain flaws exist (or have crept in). As all these fall within the purview of "technical and non-substantive editorial change," the Amendments Committee requests that the Executive Committee accept these changes at this time (see below).

The Chair plans to convene one or more meetings of the Amendments Committee in the next three months to carefully evaluate the existing document; to recommend deletions, if needed; to devise changes in existing sections, with the object of clarifying procedures within the Academy structure; and to prepare new sections, if required. Inasmuch as any changes proposed will require affirmative action by

the Executive Committee, considerable thought, discussion, and care will be required in preparing a document acceptable to the aforesaid governing bodies.

(attachment)

General Comment

The *Oxford Universal Dictionary* devotes two-thirds of a page to discussion of the pronoun “it” and the various misused or archaic derivatives of this word. Especially feckless is the version “its” which the dictionary calls a “factitious genitive.” The following ideas also emerged:

1. “Its” as a possessive. Though used by Shakespeare, the word is archaic because an inanimate object cannot “possess” anything.
2. “Its” as a contraction of “it is.” Apparently this usage is valid, though suggesting impoverished speech; the “its” substitutes for that, which, what, the one that, etc. IF “its” is used, reference is to the immediately preceding noun. In this sense, there are some bizarre constructs in our governing document.

The following changes/substitutions, therefore, are called for.

Constitution

Article 1, Sec. 3, last line: Change to read “...provided in the annual budget or previously approved by the Academy Council.”

Article IV, Sec. 3, line 1: Delete “its.”

Bylaws

Article VI, Sec. 4(2), line 10: Change to “...present the proposed change...”

Article VI, Sec. 4(18), lines 8 and 9: Modify this to read “...that the State charter and continued financial support from the State constitute an obligation...”

Article VII, Sec. 1, line 2: Delete “its” (see subsequent discussion of additional changes in Article VII).

Article VII, Sec. 3, line 8: Delete “it”; insert “Junior Academy Council.”

Article VII, Sec. 3, line 12: Delete “of its”; have the sentence read “...shall designate one member as Director...”

Article IX, Sec. 9, line 1: Delete “its”; have sentence read “...offer services to any organization...”

Article XIII, Sec. 1(5)(a), line 1: Delete “its.”

Article XIII, Sec. 1(5)(e), line 1: Delete “its”; substitute “Academy.”

The following, non-substantive changes are suggested to improve readability, clarify statements, or “repair” items which should have been changed as a result of amendment or existing procedures of the Academy.

Constitution

Article V, Sec. 1, line 1: Put “*de facto*” in italics.

Article V, Sec. 1(1), line 3, and Sec. 1(3), line 3: Put “*ex-officio*” in italics.

Article V., Sec 2: Delete all of the second sentence after the word “Chair” and end the sentence at that point.

Article VI, Sec. 2, last line: “...of the meeting date.”

Article VII: Change “Committees” to “committees” in lines 7 and 11.

Bylaws

Article II, Sec. 2, line 3: Change “to be” to “as.”

Article V, Sec. 3, line 9: “...prior to signing by the Treasurer.”

Article VI, Sec. 1, line 3: Change to read “...each committee shall determine appropriate rules and operational procedures.”

Article VI, Sec. 3(2): Put “*ex officio*” in italics.

Article VI, Sec. 3(7), line 5: Modify to read “...documents updated...”

Article VI, Sec. 4(2), line 5: Capitalize to read “Constitution”; line 8: Capitalize to read “Committee.”

Article VI, Sec. 4(9): Last two lines should read, “The Chair of the Local Arrangements Committee is an *ex officio* member of the Budget Committee.”

Article VI, Sec. 4(12), lines 7 and 8: Should read “...except that incumbents may be presented unopposed, unless there are additional nominations from the membership.”

Article VI, Sec. 4(13): Renumber from “11” to “13”; on line 6, italicize “*ex officio*”; on line 9, the first word should be “sites”; the last sentence, commencing with line 17, should read, “The Chair of this committee is an *ex officio* member of the Budget Committee.”

Article VI, Sec. 4(14): Heading should read “Publications Committee”; on line 2, insert a colon after “members”; the sentence starting in the middle of line 4 should read, “One of the latter five shall serve...”

Article VI, Sec. 4(18): Reorder the sentence that starts on line 4 to read “...authorized to solicit, in coordination with the Executive Director, financial support from foundations and other sources.”

Article VI, Sec. 4(20): Should read, “This Committee shall select a special lecturer from amongst The Academy membership to deliver a lecture at the Annual Meeting, and to four or five colleges in the State of Indiana during the academic year. The appointment shall be made and the name communicated to the Executive Committee by June 1st of each year. This program will be supported financially by the Academy by means of a special honorarium to the selected speaker.”

Article VII, Sec. 2, line 1: “Each program shall have...”

Article VII, Sec. 3, line 10: Change "policies" to "rules"; the same change should be made in Sec. 4, line 1.

Article X: The last line should be "...in advance of the meeting date."

Article XIII, Sec 1(2): Change to read "...earnings and other assets..."

Article XIII, Sec. 1(5)(a through e): Delete the "to" at the end of each section; other changes also, so that these sections probably should now read:

- (a) lend any income or assets without receipt of adequate security and a reasonable rate of interest;
- (b) pay any compensation, in excess of a reasonable allowance for salaries or other compensation, for personal services actually rendered;
- (c) make any services available on a preferential basis;
- (d) make any substantial purchase of securities, or other property, for more than adequate consideration in money or money's worth;
- (e) sell or dispose of any substantial part of Academy securities, or other property, for less than adequate consideration in money or money's worth;
- (f) engage in any transaction which results in substantial diversion of income or assets to a person who has made substantial contribution to The Academy.

Article XIV. Modify to read, "In the event of dissolution of the Academy, the assets shall be distributed..."

ESTABLISHMENT OF AN INDIANA BIOLOGICAL SURVEY AND MUSEUM OF NATURAL HISTORY

Current Situation

With the establishment of a new administrative order within the Federal Government, a unique opportunity has arisen for funding opportunities for natural history research. The Secretary of the Interior has gone to considerable effort to design a "new" agency which will be responsible for the development of a national survey of biological organisms. The National Biological Survey (NBS) as research agency will evaluate long-term trends in status and water quality for determining the effects of land use change on the environment and ecological aspects. The NBS in cooperation with the Smithsonian Institution will facilitate the collection, identification, and analysis of annual watershed, terrestrial, and multi-media surveys. The Smithsonian in turn will rely on existing natural history collections for completing the regional taxonomic identifications necessary for such an ambitious project.

Problem

The State of Indiana has lost much of its natural history resources. The University systems previously responsible for natural history research have orphaned collections and sold them to neighboring (e.g., Ohio) and often distant museums (e.g., California Academy of Science and New York State). Due to these practices, cascading events have caused the loss of integral positions within the

University systems responsible for educating and researching the native fauna and flora of Indiana. Currently, no State repository exists which is capable of handling, processing, and providing the kind of information available for a resource agency such as the NBS, US Environmental Protection Agency's Environmental Monitoring Assessment Program (EMAP), and the US Geological Survey's National Water Quality Assessment Program (NAWQA). The establishment of a museum and research capability within the State is necessary for addressing needs and providing a living resource of natural history information.

Considerations

1. With the establishment of the NBS during Federal fiscal year 1994, the explosion of EMAP, Regional EMAP, and NAWQA activities in Indiana, and the turn towards watershed management by the USEPA, State of Indiana, and other resource agencies, a definite need exists for natural history information.
2. Funding mechanisms from numerous options will exist totaling millions of dollars for each State from previous sources (e.g., NSF) and new sources (e.g., EMAP, NAWQA, BEST, GAP, and R-EMAP).
3. Likewise, the continuation of lost natural history information and resources from Indiana can no longer be tolerated without further decline of future generation capabilities in systematic and taxonomic research.

Plan of Action

1. The Indiana Academy of Science needs to take the lead in establishing an Indiana Biological Survey (IBS) which can complement the mission of the new NBS and provide the taxonomic and specialized expertise necessary for the new Agency and other Federal and State Agencies responsible for management and protection of the environment. The Academy, which is responsible for promoting the spread of scientific endeavor and promoting research opportunities, would be the best vehicle to get the IBS established.
2. The IBS will capitalize on the current distribution of researchers and experts already in the State, ensuring that these resources remain within the State and will provide an opportunity for future generations of Indiana naturalists.
3. The IBS will be self-supporting, providing additional monetary revenue for the Academy for continued support of this mission. The IBS will obtain monies by several mechanisms:
 - a. **Living Resource.** Unlike current museum collections which are only documenting species presence and absence, the IBS will monitor the environment by providing current information on the status and trends of various components of the aquatic and terrestrial communities of Indiana. The data being collected would be valuable to resource agencies and the NBS for completing their mission as

well as benefit the researchers of Indiana and the citizens of Indiana by establishing baseline information and biological criteria necessary for monitoring the natural resources of Indiana. The information can be obtained either through being a cooperator (agency annually supporting the IBS) or through a pay-per-need basis (charge for information in the data base).

- b. **Publications.** The generation of supporting literature, monographs, State distribution books, and taxonomic revisions based on Indiana material would be required by member scientists to promote the IBS. These would be available for a nominal charge but would also be self-supporting and possibly generate revenue.
- c. **Grant Opportunities.** By having a collective assemblage of natural history researchers under a single umbrella, the funding opportunities will be greater by indicating to NSF, EMAP, NAWQA, and other programs that Indiana is serious about establishing her position as a leader in natural history research. NSF grants which are currently unavailable to single institutions could now be sought for joint use within the State.

INDIANA BIOLOGICAL SURVEY (IBS) IMPLEMENTATION STRATEGY

Implementation

1. Completion of an up-to-date directory of collections and collectors. This step is already in progress and will be on-going over the next few years.
2. Fall meeting to assess what are the user needs that an IBS must address. Tom Simon, EPA, will be primarily responsible for organizing the meeting. We hope that the participants (users) at this planning meeting will include IDEM, DNR, EPA, F&WS, NOA, USFS, Army Corps of Engineers, DOT, and National Lake Shore.
3. Develop a computer interface strategy that can meet those needs. This effort will largely be steered by Ron Hellenthal, University of Notre Dame.
4. Preserve/document database through dynamic collections. This effort will largely be steered by John Whitaker, Indiana State University. Note that our strategy is that natural history collections will be preserved in Indiana as they are shown to be a valuable and necessary part of providing information on biodiversity, endangered species, and exotic species to users. Further, we anticipate that users will either contract or subscribe to receive this information in a manner similar to the Nature Conservancy's Heritage Database.

Role of the Academy

1. To act as the umbrella organization and, as feasible, house IBS's data/specimen manager (dependent on IAS setting up a central office).
2. Provide seed money for start-up workshops and equipment; long term support will come from end users, clients, and grants.

What the Biological Survey Committee Seeks from the Council

The Biological Survey Committee (BSC) asks the Council:

1. To approve the ideas that there is a need for an IBS, that the approach offered by the BSC has merit, and that the BSC should continue its planning activity.
2. To support BSC's next step which is to make arrangements for a fall meeting to discuss user needs. This meeting will need space and refreshments at the November IAS meeting.
3. To expect future proposals for workshops to evaluate alternative models for organizing a collections' database and to establish standards for survey work that is to become incorporated into the IBS database.

RESOLUTION OF THE NATURAL AREAS COMMITTEE

Biodiversity is a matter of great concern throughout the world and is of great value to humans of all nations including the inhabitants of Indiana. Our respect for and need to preserve our biodiversity is documented in the Indiana Nature Preserves Act by the Indiana Legislature in 1967 and in many journal articles.

Whereas: The vernal flora of the Eastern Deciduous Forests within the State of Indiana are valued for their beauty and diversity within the Indiana State Parks and Nature Preserves; and

Whereas: The vernal flora is of proven value to the forest ecosystem in the recycling of nutrients; and

Whereas: The forest ecosystems of the State depend on the growth and survival of seedlings and saplings of the woody species for continued vitality of the forest; and

Whereas: All or most of the native large predators have been missing from the forests of Indiana for more than half a century; and

Whereas: Recent scientific studies of the vernal flora and woody seedlings from the forests of two State Parks have shown significant reductions in diversity, cover, and biomass due to browsing by the white-tailed deer, *Odocoileus virginianus*; and

Whereas: The biodiversity and economic importance of Indiana's forest lands are too important to risk depletion of these resources due to over browsing; be it

Resolved: That the Indiana Academy of Science requests the Governor of the State of Indiana to implement the recommendations of the Brown County State Park Deer Study Commission in State Parks showing significant impact of excessive deer browsing.

MEMORANDUM OF THE NOMINATIONS AND ELECTIONS COMMITTEE

Steps in the functioning of the Nominations and Elections Committee:

1. Briefly meet with the Committee to establish procedures.
2. Determine *Newsletter* deadline for the spring.
3. Prepare request for candidates to be included in the *Newsletter* – include the deadline and indicate that 15 individuals should support the nomination.
4. Send to the Committee (if time permits) for suggestions.
5. Send to the *Newsletter* Editor.
6. Send letters to several active members of the Academy requesting suggestions for individuals to consider for nomination.
7. While waiting for petitions, contact the Committee for suggested nominees – also contact chairs of elected committees for the suggestions of their committees.
8. Contact individuals whose terms are expiring to see if they wish to run again. (Incumbents may run unopposed.)
9. If petitions do not have 15 signatures, contact the Committee Members for reactions or contact the nominees requesting additional signatures.
10. Candidates are nominated to the position.
11. Candidates are contacted, if there was no petition.
12. Candidates accept/reject nomination.
13. If the nomination is accepted, nominee must send acceptance letter along with a professional vita.
14. If the nomination is rejected, other candidates must be contacted.
15. Professional vita for each candidate is condensed to fit in the election issue of the *IAS Newsletter*.
16. The ballot is typed.
17. The vitae are edited.
18. Send edited vita to each candidate for corrections and/or minor modifications.
19. Nominations and Elections Committee members also are given an opportunity to proof the information on each candidate.
20. After corrections and/or minor modifications are made by all parties involved, the vitae are ready for printing in the *Newsletter*.
21. Take the ballot to the printer.
22. Make arrangements for return-guaranteed-postage postcards.
23. Send printed ballots to the *Newsletter* Editor.
24. Count return ballots with 2 other IAS members and record the results.
25. Present a report of the election results to the Academy.
26. Send letters of congratulations or regret, if the President does not wish to do so.
27. Give the ballots to the IAS Secretary.
28. Prepare a bill for returned ballots and present it to the Treasurer.

REPORT OF THE AUDITING COMMITTEE

The financial records of the Indiana Academy of Science for fiscal year 1993 have been examined and appear to be a fair and accurate record of the financial condition of the Academy.

Robert J. Olsen
Department of Chemistry
Wabash College
Greencastle, IN 46135

John Ricketts
Department of Chemistry
DePauw University
Crawfordsville, IN 47933

INDIANA ACADEMY OF SCIENCE

1993 Year End Financial Report

	Beginning Balance 1/1/93	Revenues	Expenses	Ending Balance 12/31/93
OPERATING FUND				
Dues		\$23,671.00		
Interest		\$2,226.66		
Contributions		\$462.25		
Deferred 1994 Income		\$2,500.00		
Spring Meeting		\$881.00	\$1,395.38	
Annual Meeting		\$8,387.00	\$17,219.77	
Officers Expenses			\$6,032.15	
Operating Expenses			\$5,881.59	
Financial Expenses			\$1,052.85	
Newsletter Expenses			\$3,620.53	
Library Operations			\$1,803.75	
Committee Expenses			\$287.76	
Speaker of the Year			\$700.00	
AAAS Representative			\$750.00	
Biological Survey			\$0.00	
Youth Activities			\$4,752.29	
Operating Fund Total	\$19,867.89	\$38,127.91	\$43,496.07	\$14,499.73
RESTRICTED FUNDS				
Proceedings	\$1,272.62	\$17,783.40	\$18,143.07	\$912.95
Publications	\$13,395.06	\$64,973.04	\$62,180.94	\$16,187.16
Research Grants*	\$2,878.07	\$37,123.79	\$38,061.79	\$1,940.07
IAS Talent Search	\$4,962.27	\$3,596.00	\$3,545.94	\$5,012.33
Lilly Library	\$6,656.12	\$0.00	\$0.00	\$6,656.12
Welch Fund	\$6,368.87	\$462.27	\$0.00	\$6,831.14
Exotic Species	\$1,583.17	\$1,000.00	\$0.00	\$2,583.17
TOTAL FUNDS	\$56,984.07	\$163,066.41	\$165,427.81	\$54,622.67
FUNDS ON DEPOSIT				
		Deposits	Withdrawals	
Checking Account	\$1,378.53	\$159,635.89	\$158,492.12	\$2,522.30
Money Market Savings	\$22,565.41	\$29,425.41	\$35,000.00	\$16,990.82
Cert. of Deposit	\$33,040.13	\$2,069.42	\$0.00	\$35,109.55
Total Funds on Deposit	\$56,984.07	\$191,130.72	\$193,492.12	\$54,622.67
FOUNDATION ACCOUNTS				
		Carrying Value 12/31/92		Carrying Value 12/31/93
John S. Wright Fund		\$742,083.71		\$741,590.36
Invested Income Fund		\$216,104.60		\$207,385.00
IAS Foundation Fund		\$71,015.96		\$73,685.51
TOTAL FUNDS		\$1,029,204.27		\$1,022,633.87

*Includes 36 senior grants and 13 high school grants

Audited 23 April 1994

Edward L. Frazier, Treasurer



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Volume 103, No. 1-2 (1994)

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